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GENERAL

Analytical Methods in Applied Mechanics 842
Computing Methods and Computers 843
Analogies 845
Kinematics Rigid Dynamics and Oscillations 845
Instrumentation and Automatic Control 847

MECHANICS OF SOLIDS

Elasticity 849
Viscoelasticity 853
Plasticity 854
Rods, Beams and Strings 857
Plates, Shells and Membranes 858
Buckling 862
Vibrations of Solids 865
Wave Motion and Impact in Solids 867
Soil Mechanics: Fundamental 869
Soil Mechanics: Applied 870
Processing of Metals and Other Materials 871
Fracture (Including Fatigue) 872
Experimental Stress Analysis 872
Material Test Techniques 873
Properties of Engineering Materials 874
Structures: Simple 876
Structures: Composite 879
Machine Elements and Machine Design 880
Fastening and Joining Methods 881

MECHANICS OF FLUIDS

Rheology 882
Hydraulics 882
Incompressible Flow 885
Compressible Flow (Continuum and Noncontinuum Flow) 886
Boundary Layer 889
Turbulence 892
Aerodynamics 893
Vibration and Wave Motion in Fluids 894
Fluid Machinery 897
Flow and Flight Test Techniques and Measurements 899

HEAT

Thermodynamics 900
Heat and Mass Transfer 901
Combustion 906
Prime Movers and Propulsion Devices 906

COMBINED FIELDS AND MISCELLANEOUS

Magneto-fluid-dynamics 908
Aeroelasticity 910
Aeronautics 910
Astronautics 910
Ballistics, Explosions 913
Acoustics 913
Micromeritics 915
Porous Media 917
Geophysics, Hydrology, Oceanography, Meteorology 917
Naval Architecture and Marine Engineering 919
Friction, Lubrication and Wear 921

Nonlinear Oscillations, R. M. Rosenberg, 837

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APPLIED MECHANICS REVIEWS

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NONLINEAR OSCILLATIONS

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INTRODUCTION

More than ten years have elapsed since the first survey article dealing with oscillations of nonlinear systems appeared in these pages and nearly five since the second. Logically, they should now be followed by a third, summarizing the advances and important results achieved since 1957. As its predecessors in this (otherwise) distinguished series of survey papers, the article should be short and instructive, it should orient the non-specialist in the state of the art, and it should lay just claim to a certain measure of completeness.

In an attempt to achieve this end, more than 900 items (written in five different languages) were examined; some 400 of these were published since 1957. Included in the latter are four books and monographs totalling well over 2000 pages; several books and proceedings which contain exclusively papers dealing with ordinary, nonlinear differential equations; and many recent survey articles, none of which lists less than 40 references. One of these dealing with an important special branch within the domain of nonlinear problems lists 157 references, taking up the last 9 pages of a 36-page article. It is evident that the researchers in this field have not been idle in recent years.

In addition to the sheer quantity of material published, these articles and books are so varied with regard to *systems* dealt with, *methods* employed, *objectives* desired, *results* obtained, and scientists addressed, that any hope of writing a conventional survey article may be confidently regarded as hopeless. Consequently, no long list of references will be found at the end of this paper. In particular, no individual author of any scientific contribution, no matter how important, will be cited. Instead, the bibliography will consist exclusively of contributions in two categories: review articles in which the most important individual references may be found, and textbooks and monographs. Unhappily, this restriction excludes important contributions which are too new to have been mentioned or evaluated in recent survey papers, and it perpetuates the disregard for certain important contributions (primarily, but not exclusively, from Italy and France) which appear to have been ignored in the past. Nevertheless, the limitation appears to be necessary since opening of the flood gates invites inundation.

THE "NONLINEAR MECHANICS:"

The reason for the heterogeneity of research work in the domain of nonlinear problems resides largely in the difficulty to properly define (and circumscribe) the subject matter comprised in it. A major contribution to the existing chaos has been the choice of the particular words "nonlinear mechanics." Even when this is restricted to mean exclusively "oscillations of nonlinear systems" or more briefly "nonlinear oscillations," it does not describe a well-defined and manageably small area such as that of "linear oscillations." A comparable situation would arise if all items and individuals in the world were to be divided into *bananas* and *non-bananas*. Surely, a survey article on non-bananas would be an awesome thing.

In attempting to define the area of nonlinear oscillations, one may use a mathematical or a physical description.

In mathematical terms, we shall only consider systems of ordinary nonlinear differential equations of which one, several, or all are nonlinear. In fact, all systems are excluded which are not of the form

$$\dot{x}_i = f_i(x_1, x_2, \ldots, x_n, \alpha_1, \alpha_2, \ldots, \alpha_m, t), \qquad (i = 1, 2, \ldots, n)$$

In these equations, the x_i are dependent variables, t is the independent variable, the α_j, $(j = 1, 2, \ldots, m)$ are system parameters, and at least one of the f_i is a nonlinear function of the x_i. If any f_i depends explicitly on t, it is periodic in t of least period T_i.* Usually, n is an even number, and $r = n/2$ is the number of degrees of freedom of the system; however, half-degrees-of-freedom are not excluded.

While this description serves to exclude a large class of problems, it is still much too broad to be useful as a definition of all those which are *in*cluded. For instance, one could easily construct systems which have no periodic or oscillatory solutions, and which are of the above form. These must obviously be excluded from the topic of nonlinear oscillations.

In physical terms, we consider only physical systems whose behavior is governed by nonlinear, ordinary differential equations. These equations are usually of the form

$$\ddot{y}_i = f_i(y_1, \ldots y_p, \dot{y}_1, \ldots, \dot{y}_p, \alpha_1, \ldots, \alpha_m, t), \quad (i = 1, \ldots, p)^{**}$$

where the independent variable t is time, the y_i are displacements (in a very general sense including linear or angular displacements, voltages, currents, condenser charges, etc.), the $\dot{y}_i$ are velocities, and the α_i are system parameters. The

*This last stipulation excludes some investigations which might be properly included in the subject of nonlinear oscillations.

**These equations can be shown very simply to constitute a special case of those given earlier.

functions f_i are sums of individual terms each of which is a force per unit mass (in a very general sense, as above). The physical meaning of "non-linearity" is that a plot of such an individual force term at a given value of time, plotted as a function of the displacement (or velocity) on which it depends does not result in a straight line. If time t appears explicitly in one or more of the governing equations, some exterior agent acts (usually) on the system;* this is either a force, or one or more points of the system are made to move in some prescribed fashion. When this is the case, the force (or the forced motion) is vibratory.

The quantity of interest in physical systems is the time history of the motion.

THE MOTIVATION:

Since the problem of nonlinear oscillations can be formulated in terms of nonlinear differential equations, it is only natural that one group of scientists motivated to study these systems consists of professional mathematicians. Writing largely for professional mathematicians, these investigators wish to learn all worth knowing about the solutions of the differential equations. They bring powerful modern methods of analysis, in particular topological methods and asymptotic integration, to bear on such questions as existence, uniqueness, boundedness, long- and short-term stability, conditions for the existence of *periodic* solutions, etc. Since these are investigations in *mathematics*, the problems dealt with, while important to the mathematician, are at times quite uninteresting to the physicist. Consider, for instance, the so-called structurally stable systems. These are systems whose solutions are only slightly affected by small changes in the coefficients of the equations. Since the coefficients of equations arising from practical problems are not known with complete precision, an examination of structurally stable systems may be thought to be motivated entirely by practical considerations. However, if the study is limited to structurally stable systems, the important problem of the point mass, suspended from a massless nonlinear (or linear) spring, and executing free vibrations is excluded since that system is not structurally stable. In fact, all systems whose phase-portraits (see the section on methods) have vortex points are not structurally stable.

The second large group of scientists examining nonlinear systems are the engineers and physicists. They may be motivated by a variety of interests. For instance, they may want to explain observed phenomena which cannot be accounted for by linear theory, or they may wish to explore whether phenomena, discovered theoretically, can actually be observed in physical systems, or they may want to introduce into a system (or make use of existing) nonlinear elements to produce certain optimum responses to prescribed excitations. In general, the interest of the physical scientists regarding the systems under investigation is more detailed than that of the mathematicians. For instance, they wish to know (within certain bounds of accuracy) what the solutions actually are, not merely whether they exist and are unique. Physical scientists cannot be satisfied with the observation that a given method of analysis converges to the solution unless the convergence is sufficiently rapid to assure reasonable, rather than lavish, expenditures of time and effort.

Unquestionably, the physical scientists have examined systems, observed phenomena, and found results which should be stimulating and interesting to their mathematician colleagues. Similarly, the mathematicians have explored systems, devised methods, and found theorems which are of importance to the physical scientist. Unfortunately, the specialization of each group has, by and large, prevented the sort of communication which would permit each group to draw the maximum benefit from the efforts of the other.

THE SYSTEMS:

Whether the approach to the problem is mathematical or physical, the systems which are under attack fall into two broad groups: those which are nearly linear, and those which are strongly nonlinear. As may be expected on intuitive reasoning alone, the examination of slightly nonlinear systems is a great deal simpler than that of strongly nonlinear ones.

There are, however, other viewpoints from which the systems may be divided into groups. For instance, when t does not occur explicitly in the differential equations, the system is called autonomous, otherwise non-autonomous. Thus, the *free* vibrations of a system are usually governed by autonomous equations, the *forced* vibrations by nonautonomous ones.

Systems are conservative when the f_i are derivable from a potential function, otherwise nonconservative. For instance, when the f_i arise only from energy-storing devices (such as springs or condensers) the system is conservative; when energy-dissipating or energy-releasing elements (such as dampers, or positive or negative resistors) contribute to any of the f_i, the system is nonconservative.

Systems may have one, or a finite number, or an infinity of degrees of freedom. The degrees of freedom may be statically coupled, or inertially coupled, or both. And, unlike the linear problem, the coupling cannot be always transferred from one type to the other simply by choosing a different set of coordinates.

Finally, systems may be "continuous" or "discontinuous." In continuous systems, the f_i are continuous functions of their arguments, in discontinuous systems they are not. The latter are very important in physical systems. For instance, in a thermostatically controlled heating system, the heat input is zero until the temperature falls to a certain minimum threshold value. When this is reached, the heat input suddenly takes on a positive value until the temperature reaches a (second) maximum threshold value; then, the heat input drops back to zero. Similarly, the thrust on a missile may be a nonzero constant until a certain altitude (or time) is attained; then it becomes zero.

While other viewpoints may be used to divide nonlinear, oscillating systems into still different groupings, the more important ones have been mentioned here.

THE BEHAVIOR:

Whether the investigator is a mathematician or a physical scientist, his aim is invariably to deduce the behavior of the system—i.e., to solve the differential equations. These solutions are usually the end product of the investigation; however, in the theory of automatic controls of nonlinear systems, the purpose is not only to find the solutions, but to use the knowledge, so-gained, in the construction of systems behaving in some optimal fashion.

The behavior of nonlinear oscillating systems is of two kinds: there are phenomena which have counterparts in related linear systems,** but which are distorted in some manner because of the nonlinearity, and there are those which are strictly due to the nonlinearity and for which no parallel

*Exceptions to this statement exist. See for instance the problem of the locomotive side-rod.

**The "related linear system" is usually the one whose differential equations of motion are obtained by deleting the nonlinear terms from the equations under study.

exists in linear systems. These two types are frequently interwoven. For instance, the familiar frequency-amplitude plot of steady-state vibrations of linear systems having a single degree of freedom (frequently called the "reasonance diagram") is "bent" due to spring nonlinear ties and, the stronger the nonlinearity the greater the "bending." Thus, nonlinearity produces merely a distortion of the related linear phenomenon. However, due to it, the system can now vibrate at more than one amplitude even though the parameters remain unchanged; moreover, these steady-state vibrations may be stable or unstable. The occurrence of a multiplicity of steady states and of unstable steady states has no counterpart in the related linear problem.

In general, the interest in vibrations of nonlinear systems centers on the vibrations of large amplitudes. (Usually, the mechanical engineer wishes to avoid them, and the electrical engineer to produce them.) In nonlinear systems, vibrations of large amplitude may occur, both in autonomous and in nonautonomous system. In the former, where no exterior force acts to excite them, the vibrations are self-excited. The most interesting, and the most widely investigated, case of self-excited vibrations is the so-called *relaxation oscillation.* It occurs in physical systems obeying van der Pol's or related equations, and it has no counterpart in related linear systems. The theory of relaxation oscillations is capable of explaining such phenomena as tool chatter, the vibrations of stringed instruments *when bowed,* and it is utilized by electrical engineers in the so-called relaxation oscillator. In nonautonomous systems, vibrations of large amplitude may occur because of instability, or because of phenomena akin to the reasonance of linear systems. The most important new phenomena—i.e., those due to the nonlinearity—are frequency demultiplication or subharmonic resonance, and combination oscillations.

In subharmonic resonance, the steady-state response to a periodic forcing function of frequency ω is a vibration of frequency ω/n where n is an integer. There appears to be a fundamental difference in even-ordered and in odd-ordered subharmonics. The first occur predominantly (and perhaps only) in systems where the forces acting on the system are unsymmetric—i.e., where the forces arising from displacements in one direction are different in magnitude and/or in sign from those arising out of displacements in the opposite direction. Thus, even-ordered subharmonics are not likely to occur in systems having springs that resist displacements (or dampers that resist velocities) in equal measure, whether positive or negative.

Combination oscillations occur in systems obeying the van der Pol-type equation, and forced by an external periodic exciting force. The difference between the frequency of the self-excited free nonlinear oscillation and that of the exciting force is called the detuning. Combination oscillations (which are not unlike beats) occur in these systems when the detuning is large.

Related to combination oscillations is the typically nonlinear phenomenon of "entrainment." Combination oscillations, being composed of a combination of the free and forced motions, result in an oscillatory motion of periodically modulated amplitude. However, when the detuning is sufficiently small, these beats disappear and the motion becomes periodic with the same frequency as that of the exciting force. This phenomenon is known as frequency entrainment because the forcing function captures or "entrains" the motion.

A topic which is rarely of interest in the oscillations of linear systems is that of "stability of periodic motion;" yet this is a matter of prime concern in nonlinear oscillations. In a loose manner of speaking, stability is usually thought of in the following way: If the solution of a system of n first-order ordinary differential equations is given by n functions $x_i(t)$, $(i = 1, \ldots, n)$, then these can be represented as a single curve in a space of $n + 1$ dimensions, the dimensions being x_1, $x_2, \ldots, x_n$ and t. If any other solution is represented by a second curve which has one of its points near an ordinary point of the first one, the first solution is called stable if the second one lies "almost everywhere near" the first one. It will be noticed that the word "near," used here, has not been defined, and that the word "almost" is ambiguous. It is in the definition of these words that many concepts of "stability" differ. There is one important paper in the recent literature that has as many as nine different definitions of stability. Most investigators dealing with stability distinguish among at least two or three different types.

In a review of progress in the theory of stability one very powerful method of analysis, known as "Lyapunov's second method," cannot be ignored. Actually, this method is not new; it was made available in a western language as early as 1907. However, it remained the exclusive property of mathematicians for many years.

In recent years, individual papers have appeared frequently which applied Lyapunov's second method to practical problems. However, it was not until the publication of Lurie's book (in Russian in 1951, and in German and English in 1957) that a systematic presentation of its application to physical problems became easily accessible.

This is not the place to discuss the many and difficult details of what one mathematician calls "that much overburdened word with an unstabilized definition"—stability. Let it be sufficient to say that unstable periodic solutions exist in a mathematical sense, but cannot be observed in physical systems. In this respect they are like unstable equilibrium positions; a frictionless pendulum can remain at rest when inverted, but experiment cannot be used to verify this statement.

When a periodic solution is unstable, the physical system will execute a motion which may oscillate or diverge. The amplitude of the motion may grow "indefinitely," or it may grow until some bound is reached. In other cases, the "amplitude" may not grow at all, but the motion may become erratic. Probably, the chaos surrounding the meaning of "stability" should be increased by carefully distinguishing between unstable *systems* and unstable *solutions,* in addition to the distinction between the various types of stability.

THE METHODS:

The methods used to deduce solutions of nonlinear differential equations, or at least some properties of the solutions, vary widely. In general, one can probably say with justification that the mathematicians use methods which make the physical scientist raise his eyebrows, and the physical scientists use methods which make the mathematician shudder. The basic reason for this dichotomy is not difficult to see; it lies in the motivation of each group. The mathematician usually concerns himself with very broad classes of problems, and with very general questions regarding the solutions. His methods must be fitted to these quests. Thus, methods which might produce approximations of unknown accuracy to particular solutions of individual problems can not serve him. The physical scientist, on the other hand, has a long-standing and often fruitful habit of intermingling mathematical and physical arguments, and he frequently relies on intuition to guide him. Moreover, he is likely to regard the results of a physical experiment as a proof (sometimes the only proof) of the correctness of his methods. Such procedures are, quite naturally, unacceptable to the mathematician.

In general, the methods used to examine nonlinear problems vary with the type of problem under study. It is relatively rare

that the same method is effective in all types of problems. Moreover, the methods used must be adapted to the type of answer sought. Methods giving only qualitative information are almost never useful for quantitative results, and methods effective in the latter quest are much too laborious for qualitative results "in the large."

In single-degree-of-freedom (conservative or nonconservative) autonomous systems, the method, called by some physical scientists "topological" and referred to by topologists as the "phase-portrait" discussion, is very useful. This method deals with solutions, or integral curves, of the equations in the displacement-velocity-space called the phase-space. Periodic solutions are represented in this space by closed curves since displacement and velocity recur after one period. Oscillations which are not periodic are spiral-like curves since displacement and velocity pass often through zero values. Many general theorems regarding the integral curves in the phase-space are known, and very general results regarding the character of the solutions can be deduced by very simple tests. In fact, the generality of the results that can be found from an examination of a very limited portion of the phase-plane portrait belongs to one of the truly beautiful facets of the theory of nonlinear differential equations. While the phase-plane method has been largely used for systems of only two first-order equations—i.e., systems having a single degree of freedom—it can be, and has been, extended to systems of more than one degree of freedom. However, the complications increase rapidly with the number of degrees of freedom. This is not only due to the difficulties surrounding the visualization of geometry in a large number of dimensions, but also to the complicated character of singular points in multi-dimensional spaces.

In addition to the methods used for the description of the phase portrait, there exist useful methods for constructing individual curves in the phase-plane. These are usually graphical and are variations of the method of the isoclines. The better-known ones are the isocline method, the Liénard method, and the Meissner method. The latter is an interesting variant since it can be used for nonautonomous systems as well.

All methods making use of the phase-plane have a geometrical aspect. Those which do not belong to this group are usually called analytical methods. Basically, these fall into two natural divisions: those useful only for slightly nonlinear systems, and those not so restricted.

When the system is nearly linear, the equations are of the form

$$\dot{x}_i = f_i(x_1, \ldots, x_n, t) + \lambda_i g_i(x_1, \ldots, x_n, t), \qquad (i = 1, \ldots, n)$$

Here the f_i are *linear* in the x_i, and the g_i are *not*. If either depend on time t, they are periodic of period T_i. The λ_i are constants, and they are small in absolute magnitude. Smallness is taken to mean that their squares and higher powers can be ignored compared to the λ_i themselves.

The great bulk of work on nonlinear differential equations has been carried out on these slightly nonlinear systems, called by many investigators "quasi-linear."

The reasons for the great concentration on quasi-linear systems are two-fold. One is simply a question of mathematical convenience. It is reasonable to suppose, and it can, in fact, be demonstrated in a strict mathematical sense, that certain phenomena known to exist in the related linear system are only slightly changed in the quasi-linear case. (Of course, this statement does not exclude the possibility that new phenomena may arise in quasi-linear systems which do not exist in the linear problem.)

A second and, perhaps, a more valid reason for the preoccupation with quasi-linear systems is that the majority of physical systems is governed by them. This becomes evident from the combination of circumstances that no physical system is strictly linear and, yet, linear oscillation theory has served to explain the majority of observed phenomena; in other words, most physical systems *are* quasi-linear.

The most important methods for deducing quantitative information from a quasi-linear system of differential equations are: the iteration method, the perturbation method with the closely related method of asymptotic integration, the Galerkin method, and the method of variation of parameters (which also makes use of perturbation techniques). The latter (and its slight variants) is also known as the method of van der Pol, and as the method of Krylov and Bogolyubov.

The iteration method was used by Duffing to examine solutions of the celebrated equation named after him. The method consists in adopting the solution of the related linear system as a first approximation which is, then, substituted in the right-hand sides of the system of equations. These can now be integrated twice to yield the second approximation. However, in this process there arises what has been called by Poincaré the "difficulty of the small divisors." While heuristic arguments have been constructed by Duffing and others to eliminate this difficulty, these stand on clay feet and make a convergence proof of the iteration procedure unlikely.

The perturbation method (which also has important applications in the theory of linear differential equations) relies on the fundamental idea of constructing the solutions to an unknown problem by means of those of a simpler known problem which lies close to the unknown one. In fact, the desired quanitities are developed into power series in the λ_i whose coefficients are linear differential equations that that can be solved in order. While it is possible in many important classes of problems to prove the convergence of this procedure, the method is laborious. Moreover, if there are many distinct (non-zero) λ_i, the computation of approximations higher than the first may become algebraically inextricable.

The method of the variation of parameters consists in adopting solutions which have the appearance of simple harmonic motion, but the amplitude and phase (essentially the "constants" of integration) are assumed to be slowly varying functions of time. If the problem is quasi-linear, this assumption can be shown rigorously to be correct The amplitude and phase are the solutions of a new set of nonlinear differential equations. These are integrated approximately where the approximation consists in utilizing the property that the quantities of interest vary only slowly with time.

They may be integrated to greater accuracy by applying a perturbation procedure to them. Even when the perturbation series do not converge, the method of asymptotic integration will yield answers within known accuracy.

All three methods may be applied to nonautonomous as well as to autonomous systems.

It appears that the iteration procedure is the simplest from the standpoint of computational efforts involved, but its validity is questionable. The perturbation method is the most easily applied of the well-founded methods, and the method of the variation of parameters is useful not only in actual computations, it is particularly suitable to deduce general results and theorems.

It should not be concluded from the earlier remarks that the study of nonlinear equations has been restricted to quasi-linear systems. In fact, a great deal of recently published research has been devoted to strongly nonlinear systems. Much of this effort was expended by mathematicians, and their results are rather general, dealing with existence, uniqueness, and stability of periodic solutions. Their methods have largely been "non-constructive" in the sense that they do not lend themselves to the actual construction of solutions.

Physical scientists have also considered strongly nonlinear systems. Here, their most notable advances have consisted in the examination of van der Pol's equation with strong nonlinearity, and in the study of conservative systems which are highly nonlinear. However, the major portion of their efforts has gone into the study of particular problems, not classes of problems.

The validity of their results is, at times, doubtful. This opinion is based on the observation that, frequently, the methods employed were known to yield good results in quasilinear systems *only*, and no additional efforts were made to establish their validity for the strongly nonlinear problem.

THE OUTLOOK:

The outlook regarding progress in nonlinear oscillation theory is bright for those who like to do research, and bleak for those who like to see results. Advances which would hardly merit mention in linear theory constitute triumphs in nonlinear theory. At the present time, no hope exists for a unified theory or body of knowledge regarding the solutions of nonlinear problems. The basic reason behind this statement is the failure to define the field.

If one were to define linear systems as those in which linear combinations of solutions yield solutions, one might, as a next step, single out a class of nonlinear systems by demanding that quadratic forms of solutions, say, are solutions. If this were done, it might be possible that a general body of knowledge of that class could be assembled. However, such an effort would lack physical motivation, and the history of differential equation theory demonstrates that this field has always been strongly motivated by practical problems.

The outlook for significant progress seems brightest in the field of automatic controls. This prognosis is based on the observation that the last decade has seen the greatest progress in the application of nonlinear theory to that particular field (excluding the purely mathematical contributions). Moreover, it is certainly the area of greatest activity among the physical sciences concerned with nonlinear problems.

Like few other fields (if any), that of nonlinear oscillations is characterized by a great variety of efforts, and by the admirable ingenuity that has gone into devising special methods, suitable to particular investigations of individual problems. It seems that the most significant, and the most immediate progress could be achieved by re-establishing the lines of communication between the mathematicians and the physical scientists, and between the physical scientists working in different areas.

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Analytical Methods in Applied Mechanics

(See also Revs. 5835, 5840, 5845, 5849, 5852, 5854, 5886, 5896, 5915, 5932, 5940, 6145, 6188, 6202, 6209, 6215, 6267, 6269, 6272, 6279, 6289, 6354, 6393)

Book—5807. Shtokalo, I. Z., Linear differential equations with variable coefficients [Lineinye differentsial'nye uravneniya s peremennymi koeffitsientami], Kiev, Izdatel'stvo Akademii Nauk Ukrainskoi SSR, 1960, 76 pp. 23 k. (Paperbound)

The monograph considers two general classes of equations: (a) linear homogeneous equations of the n-th order with variable coefficients, and (b) systems of linear homogeneous equations of the first order with variable coefficients. For both classes, solutions are found by asymptotic methods and the order of accuracy of the expansion determined. Criteria for stability of solutions are presented. In all, the author has skillfully tied together much known information in a compact treatise pertaining only to asymptotic solutions of these types of equations. W. Nash, USA

5808. Panichkin, I. A., Solution of a differential equation in particular derivatives (in Russian), Nekotorye Vopr. Mekhaniki (MVTU, **88**), Moscow, 1958, 103-107; *Ref. Zh. Mekh.* no. 10, 1959, Rev. 11469.

A solution is found for an equation obtained by the author when solving the problem of the flow past a body of rotation at large subsonic velocities.

$$(\eta^2 - 1)\frac{\partial^2 H}{\partial \eta^2} + (1 - \zeta^2)\frac{\partial^2 H}{\partial \zeta^2} = F(\eta, \zeta)\sum_{n=0}^{4} F_n(\eta)\zeta^{2n}$$

where F and F_n are known functions. The general solution of the homogeneous equation can be recorded in the form

$$H_0 = \sum_{n=1}^{\infty} C_n(1 - \zeta^2)P_n'(\zeta)(\eta^2 - 1)Q_n'(\eta)$$

where C_n are arbitrary constants, $P_n'(\zeta)$, $Q_n'(\eta)$ are derivatives of Legendre's polynomes $P_n(\zeta)$ and Legendre functions of the second order $Q_n(\eta)$. Treated this way the problem leads to the finding of a particular solution which is sought in the form of

$$H^* = G(\eta, \zeta)\sum_{n=0}^{3} G_n(\eta)\zeta^{2n}$$

where

$$G(\eta, \zeta) = 1/(\eta^2 - \zeta^2)^2$$

A system consisting of six equations is obtained as indicated above for four unknown functions of G_n. The author succeeds in solving these equations successively and to obtain function G_n in a clear form. D. B. Kikin

Courtesy Referativnyi Zhurnal, USSR

5809. Ehrlich, L. W., Riley, J. D., Strang, W. G., and Troesch, B. A., Finite-difference techniques for a boundary problem with an eigenvalue in a boundary condition, *J. Soc. Indust. Appl. Math.* **9**, 1, 149-164, Mar. 1961.

Problem arises in the study of small fluid oscillations in an axially symmetric tank. Several finite difference procedures for finding the smallest eigenvalue are developed. Some numerical examples illustrate the discussion. Y. L. Luke, USA

5810. Daniliuk, I. I., On the theory of one-dimensional singular equations, Problems of continuum mechanics (Volume dedicated to N. I. Muskhelishvili on his 70th birthday), Philadelphia, Soc. Industr. and Appl. Math., 1961, 93-103.

By considering more convenient assumptions regarding the coefficients of the singular part of one-dimensional integral equations of the form

$$K x(s) \equiv a(s)x(s) + (b(s)/\pi)\int_0^{2\pi} [x(t)/(1 - e^{i(s-t)})]\,dt + Lx(s) = f(s),$$

the author gives proofs of the theorems of F. Noether. The importance of these equations to the engineer lies in the fact that they are connected with problems in elasticity theory.

E. J. Scott, USA

5811. Gakhov, F. D., On new types of integral equations, solvable in closed form, Problems of continuum mechanics (Volume dedicated to N. I. Muskhelishvili on his 70th birthday), Philadelphia, Soc. Industr, and Appl. Math., 1961, 118-132.

Only a small number of integral equations are known whose solutions can be expressed in closed form. Classical examples are those of Abel and Schlomilch. Gakhov has discovered new types of integral equations having closed solutions. One such is the equation

$$a(x)\int_0^{\infty} [P(x-t)\log|x-t| + Q(x-t)]\,x(t)\,dt - \pi i b(x)\int_0^{\infty} P(x-t)\,x(t)\,dt = \tfrac{1}{2} f(x).$$

The basic idea for the solution of such equations is due to T. Carleman and consists of analytic continuation into the complex plane and transforming the problem to a Riemann boundary – value problem. E. J. Scott, USA

5812. Pogorzelski, W., On the properties of a singular integral in space and their application to a system of singular integral equations, Problems of continuum mechanics (Volume dedicated to N. I. Muskhelishvili on his 70th birthday), Philadelphia, Soc. Industr. and Appl. Math., 1961, 327-341.

Paper studies a property of a certain singular integral. This property is then applied to the solution of a system of singular integral equations in n-space by Schauder's method. With the results obtained an existence theorem is formulated for the solution of this system. Considerable mathematical maturity is required of the reader. D. Boyanovitch, USA

5813. Smirnov, V. I., On a certain class of isotropic congruences, Problems of continuum mechanics (Volume dedicated to N. I. Muskhelishvili on his 70th birthday), Philadelphia, Soc. Industr. and Appl. Math., 1961, 483-496.

This paper reviews the results of the paper "On conjugate functions, II," [*Vest. Leningr. In-ta* no. 11, 3-12, 1953] and studies a certain class of isotropic congruences in three-dimensional space in connection with functionally invariant solutions of the corresponding partial differential equations. The paper is mathematical in nature and demands considerable mathematical maturity of the reader. These solutions could be applied to some problems in the theory of elasticity. D. Boyanovitch, USA

5814. Westpfahl, K., On a theory of a class of diffraction problems using singular integral equations (in German), *Annalen der Physik* **4**, 6/8, 283-351, 1959.

A boundary-value problem for a class of two-dimensional diffraction phenomena (half-plane, grid, etc.) has been reduced to a singular integral equation of Cauchy type. The number of equa-

tions corresponds to the number of the sides of the "antennas." For a single-edge problem, the integral equation can be solved by the complex variable method of Muskhelishvili (embracing the Wiener-Hopf technique as a particular case). The double-edge problem is solved asymptotically and compared numerically with the results of the series expansion into Mathieu functions.

From author's summary by J. Nowinski, USA

5815. Collins, W. D., On the solution of some axisymmetric boundary value problems by means of integral equations: Part 4, Some scalar diffraction problems for circular disks, *Quart. J. Mech. Appl. Math.* **14,** 1, 101–117, Feb. 1961.

5816. Collatz, L., Monotonicity and extremal principle for Newton's method (in German), *Numerische Mathematik* **3,** 2, 99–106, Mar. 1961.

Newton's method for finding the zeros of a function is applied to develop an iterative process to compose the solution of a differential equation. With suitable hypotheses, it is shown that the iterants are monotonic and the usual extremal-type theorems are deduced. There are three examples, including a nonlinear equation with two point boundary conditions.

Y. L. Luke, USA

Book—5817. Brownlee, K. A., Statistical theory and methodology in science and engineering, New York, John Wiley & Sons, Inc., 1960, xv + 570 pp. $16.75.

Although the title suggests more, this is an elementary textbook intended to accompany a college course of three hours per week for three quarters and deals mainly with the Neyman-Pearson ideas of statistical inference and their applications in industrial and biological experimentation. The basic statistical theory is tersely presented, many terms (e.g. null hypothesis) being used with little or no explanation. Mathematical and arithmetical manipulations, on the other hand, are often carried through with a detailed description of every step. The book's most valuable contribution is a careful treatment of a wide variety of simple experimental designs. There is a good set of exercises, some with answers, for the reader. Indexing, printing, binding and price are of the high standards one has come to expect in the Wiley Publications in Statistics.

E. W. Bowen, England

Book—5818. Dano, S., Linear programming in industry; theory and applications, Wien, Springer-Verlag, 1960, viii + 120 pp. $4.75.

Linear programming (the planning, in an optimal manner, of independent activities) has been a very popular subject since the war, as attested by the large number of papers that have been written on techniques and the mathematical development of this subject. It has been applied to the solution of practical problems relating to production, distribution of goods, blending of fuel, labor allocation, and many others. The military have used it in combat logistics, personnel selection, procurement, etc.

The author's timely presentation of "Linear programming" brings a valuable addition to the extant literature, due to his clear exposition devoid of mathematical complexities.

The book will be greatly appreciated by those who are more familiar with ordinary algebra than with the intricacies of matrix algebra and who wish to obtain an understanding and eventual use of the algorithm of linear programming.

In nine chapters and 115 pages of well-written text, the author presents the theory of linear programming, the Simplex method illustrated by many examples and computational procedure, together with a discussion of other aspects of programming such as the merit "of Common Sense" method versus linear programming, including application in industry.

Springer-Verlag, Vienna, the publisher, has as usual produced an attractively printed and easy to read book.

M. Martellotti, USA

5819. Lemke, C. E., The constrained gradient method of linear programming, *J. Soc. Indust. Appl. Math.* **9,** 1, 1–17, Mar. 1961.

In usual simplex algorithms, approach to the solution is made by a method of steepest descent (ascent) along *edges* of the constraint polyhedron. The method proposed here is that of steepest descent (ascent) on the surface (faces) of the constraint polyhedron. Allegedly more efficient, the method is discussed in some detail, although its superiority to other methods is not shown. There are certainly problems in which the method (like most others) is not optimal; it will involve more steps than other solution procedures.

B. R. Gelbaum, USA

5820. Fulkerson, D. R., An out-of-kilter method for minimal-cost flow problems, *J. Soc. Indust. Appl. Math.* **9,** 1, 18–27, Mar. 1961.

The minimal-cost-flow problem, e.g., in electrical power systems (a special case of the general linear programming problem), is solved by a new method. At each stage in the solution to the problem, arcs that are at variance with a prescribed optimality are adjusted to optimality, while any optimality in other arcs remains undisturbed. Comparisons with other methods of solution reveal differences, but no demonstrable improvements.

B. R. Gelbaum, USA

5821. Sweeny, R. F., Davis, R. S., Lapidus, L., Roberts, S. M., and Sax, E., Mathematics, computers, operations research, and statistics, *Indust. Engng. Chem.* **53,** 4, 329–336, Apr. 1961.

5822. Klein, B., Some comments on the inversion of certain large matrices, *J. Aerospace Sci.* **28,** 5, p. 432 (Readers' Forum), May 1961.

Computing Methods and Computers

(See also Revs. 5819, 5820, 5821, 5832, 5857, 5859, 5866, 5898, 6088, 6106, 6183, 6201, 6267, 6277, 6354, 6355, 6364, 6424)

Book—5823. Thom, A., Apelt, C. J., and Temple, G. F. J., Field computations in engineering and physics, New York, D. Van Nostrand Co., Inc., 1961, vii + 165 pp. $5.75.

Book describes numerical methods for solving elliptic partial differential equations in two variables. Nonlinear problems such as the Navier-Stokes equations and the equations for inviscid compressible flow are dealt with as well as the usual linear and fourth-order equations.

The methods described differ somewhat from the relaxation methods which have been dealt with in a number of recent books. A systematic traverse correcting the function, or the difference between traverses, is advocated instead of attacking the point with the largest residual. The reviewer is not qualified to judge the relative merits of the approaches for individual cases; however, the claim that the present methods are easier to program for automatic computation appears plausible. On the other hand, the main emphasis of the book is on hand computation and no detailed discussion of machine methods is given.

Interesting features of the present methods are the use of higher-order difference formulas and of "symmetromorphic" transformations to convert configurations with curved boundaries into rectangular domains.

The chapter on the numerical solution of the Navier-Stokes equations is of particular interest in view of the authors' long expe-

rience in the field. Such problems are very laborious, an estimate of 1500 hours is given for the calculation of the flow around a circular cylinder at Reynolds number 40 (not using the present methods). In spite of the practical importance of such problems, it apparently has not yet been possible to utilize high-speed computers.

The book is well written and should be of interest to both engineers and mathematicians. The detailed examples make it suitable for individual study. W. Squire, USA

Book—5824. Langer, R. E., edited by, Frontiers of numerical mathematics (Symposium conducted jointly by Mathematics Research Center, US Army, and National Bureau of Standards, University of Wisconsin, Madison, Wisconsin, 30–31 Oct. 1959), Madison, Wisconsin, University of Wisconsin Press, 1960, xi + 132 pp. $3.50.

Purpose of symposium was to survey applied fields to identify mathematical problems which must be faced in the lines of scientific advance. The eight papers and authors are as follows: "Stress analysis in the plastic range," William Prager; "Some mathematical problems of nuclear reactor theory," Garrett Birkhoff; "Numerical problems of contemporary celestial mechanics," Zdenek Kopal; "Aeroelasticity," Lee Arnold; "Operations research," Philip M. Morse; "Mathematical bottlenecks in theoretical chemistry," Joseph O. Hirschfelder; "Magnetohydrodynamics," S. Chandrasekhar; "On the application of numerical methods to the solution of systems of partial differential equations arising in meteorology," J. Smagorinsky. Y. L. Luke, USA

5825. Griffin, J. A., Jr., A method of four-point interpolation especially adapted for treating end conditions of wings and other elastic surfaces, *J. Aerospace Sci.* **28,** 2, 161–162 (Readers' Forum), Feb. 1961.

A simple four-point interpolation formula with continuous first derivative at the mesh points is derived. For a more theoretical approach to the problem of smooth interpolation see H. Rutishauser (following review). Author also studies interpolation at the boundary under known conditions for slope or curvature.

F. L. Bauer, Germany

5826. Rutishauser, H., Notes on smooth interpolation (in German), *ZAMP* **11,** 6, 508–513, Nov. 1960.

Usual interpolation formulas for equidistant abscissae give a piecewise polynomial approximation whose first derivative is in general discontinuous at every mesh point. It is shown how these formulas can be modified without using derivatives of the given function such that a piecewise polynomial approximation has $s = 1, 2, \ldots$ continuous derivatives. A correction term results involving only the highest difference used in the usual interpolation formulas, thus decreasing the order of approximation by 1. Thus smoothness of approximation in the neighborhood of a mesh point is compensated by a slight decrease in accuracy. Explicit improved Bessel formulas are given for six points with $s = 1$ and for eight points with $s = 2$, which are practicable.

F. L. Bauer, Germany

5827. Birkhoff, G., and Garabedian, H. L., Smooth surface interpolation, *J. Math. Phys.* **39,** 4, 258–268, Dec. 1960.

A method for interpolating a function of two real variables is proposed and discussed. In some respects it is a generalization of "linearized spline" interpolation for functions of one variable. The latter is an idealization of applying a thin elastic ruler ("spline") to the given points in the plane. It results in a set of cubic polynomials, one for each grid interval, with values and first derivatives continuous across interval boundaries. Not all of the elegant properties of this method can be preserved in the transition from one to two independent variables. The authors make some arbitrary decisions to sacrifice certain advantages of one-dimensional spline interpolation while retaining others. The resulting interpolation method looks inelegant but practical. If a function u is given in the points of a rectangular grid in the (x, y)-plane, the interpolated function in one mesh rectangle is a linear combination of 12 basic functions, 9 polynomial and 3 piecewise polynomial, of degrees up to the 6th. The interpolated u and its first derivatives are continuous, but u_{xy} may be discontinuous along the grid diagonals. Along each grid line u coincides with the function obtained by one-dimensional linearized spline interpolation. While most of the paper is concerned with rectangular grids, extension to other grid shapes is discussed.

F. L. Alt, USA

5828. Chao, B. T., Li, H. L., and Scott, E. J., On the solution of ill-conditioned, simultaneous, linear, algebraic equations by machine computation, Illinois Engng. Exp. Sta. Bull. 459, 16 pp., 1961.

5829. Wynn, P., On an interpolation algorithm and certain other formulas which arise in the theory of interpolation by rational functions (in German), *Numerische Mathematik* **2,** 3, 151–182, 1960.

5830. Duck, W., Estimating the error in stepwise procedures for systems of linear equations (in German), *Numerische Mathematik* **1,** 2, 73–77, Apr. 1959.

5831. Bull, A. F., and Lihou, D. A., Computers for the chemical engineer (Proceedings of Symposium held at Birmingham University, England, Mar. 1961); Birmingham University Chemical Engineer, Suppl. July 1961, 68 pp.

These proceedings, giving a full record of the papers and discussion, afford a convenient review over the whole range of the topic. The first paper, of an introductory nature, "Computers and programming," was presented by K. A. Redish of the University of Birmingham. The second paper, "Plant management applications," presented by D. G. Thompson of the Esso Petroleum Company, Fawley, was illustrated from their experience of refinery operations. The final paper of the morning session, "Computers in distillation dynamics research" by J. E. Rynsdorp of Koninklijke/Shell—Laboratorium, Amsterdam, showed how digital and analog methods of computing are complementary. The analog system is particularly advantageous when a dynamic study is being made of response to change in system parameters. This paper also attracted much attention because of its contribution to the understanding of tray distillation column dynamics and, particularly, the influence of vapor flow variations on the liquid overflow.

The afternoon's session was devoted to computers for control. The introductory paper by L. Gallon, formerly of the British Petroleum Company, discussed "The need for more process control computation" and ranged over the full potentialities of computer control systems. The other papers of this session described three available computers of differing complexity suitable for control applications. R. J. Redding and F. H. Bodley of Eversheds and Vignoles presented their paper "Simple computing relays" which described the well-tried electromagnetic balance analog and typical applications. M. James and W. T. Lee of De Havilland Aircraft Co. Ltd. described "'Anatrol', an analogue on-line process control computer" and its potentialities. The final paper by W. F. M. Payne of Ferranti outlined "The 'Argus' digital computer for process control." The chairman of the afternoon session, J. McMillan of the I. C. I. Central Instruments Laboratory, commented how all these devices had in common the capability of operating in feed forward control systems with consequent potential improvement in control quality if the system dynamics are understood sufficiently. The

justification of the more complex control systems was questioned by some in the discussion, but there was not sufficient experience to put a conclusive financial argument.

J. S. M. Botterill, England

Analogies

(See also Revs. 5992, 6364)

Book—5832. Karplus, W. J., and Soroka, W. W., Analog methods—Computation and simulation, 2nd ed., New York, McGraw-Hill Book Co., 1959, xiii + 483 pp. $12.50.

This is an enlarged and improved version of the first edition which served as an introductory text in analog methods. The present edition is in joint authorship whereas the first one—AMR 8(1955), Rev. 1537—was by second of the present authors only. In accordance with the present trends, authors have effected a change in the emphasis from the mechanical, in the previous edition, to the electrical and electronic techniques in the present one.

The book is divided into eleven chapters; the first is introductory. It is followed by four chapters, forming first part of the book, dealing with indirect electrical and mechanical computing elements. The second part is on indirect computers and contains three chapters dealing with differential analyzers, analog solutions of linear and nonlinear algebraic equations. Third and last part is on simulators, and contains three chapters dealing with dynamical analogs, finite difference networks, and continuous field analogs. List of references is given at the end of each chapter except the first one. The book ends with three appendixes containing two tables of transfer functions, 79 problems spread over on different chapters for class room exercises, and ten laboratory experiments.

Though the plan of the present edition is similar to the previous one, thorough revision of the old material and the added information has brought the book up-to-date. It forms a good companion volume to "Analog simulation: solution of field problems" (McGraw-Hill, 1958) by W. J. Karplus, first author of the text being reviewed. These books together form a good prelude to the book by Smith and Wood on "Principles of analog computation" [McGraw-Hill, 1959; AMR 13(1960), Rev. 4986]. A study of these three books will give a comprehensive understanding of the subject of analog computations. B. M. Belgaumkar, India

5833. Ondra, O., Moment-distribution constants from cardboard analogs, *Proc. Amer. Soc. Civ. Engrs.* **87,** ST 1 (*J. Struct. Div.*), 73–102, Jan. 1961.

5834. Redshaw, S. C., Use of an electrical analogue for the solution of a variety of torsion problems, *Brit. J. Appl. Phys.* **11,** 10, 461–468, Oct. 1960.

Kinematics, Rigid Dynamics and Oscillations

(See also Revs. 5852, 5854, 5863, 6003, 6008, 6009, 6032, 6107, 6321, 6361)

5835. Polecudi, C., and Calcan, V. I., Mechanisms of cyclic curves. Contribution to the synthesis of mechanisms of cyclic curves (in French), *Rev. Mécan. Appl.* **5,** 4, 497–517, 1960.

Using plane vectors represented by complex numbers, authors analyze cyclic curves (simplest example: cycloids) of order $S-1$ generated by open linkage of S links with different but constant angular velocity ratios assured by gearing at each junction, or by certain parallelogram mechanisms. In a stationary, rotating or translating plane of reference, they derive equations of curves, velocities, accelerations, curvature, tangents and normals, axes of symmetry, revolutions per period for each link, singular points, intersections with arbitrary straight line. They cover number of ways of generating the same curve, determination of simplest (prime) gearing, and application to the synthesis of epicycloid generators consisting of two geared links. Generation of technically useful curves is implied. G. N. Sandor, USA

5836. Polecudi, C., and Calcan, V. I., On the synthesis of mechanisms describing high order cyclic curves (in English), *Rev. Mécan. Appl.* **5,** 6, 739–752, 1960.

Paper describes method of synthesizing a mechanism to produce high-order curves with emphasis on polygons. The mechanism has hinged links driven by gears whose centers are at the hinge points. The dimensions are governed by geometric and kinematic considerations. The desired curve is expressed in terms of a Fourier series and the coefficients are used to determine the dimensions of the mechanism. Procedure is illustrated by an example. A. H. Church, USA

5837. White, J. S., and Hansen, Q. M., Study of systems using inertia wheels for precise attitude control of a satellite, NASA TN D-691, 71 pp., Apr. 1961.

Systems using inertia wheels are evaluated in this report to determine their suitability for precise attitude control of a satellite and to select superior system configurations. Various possible inertia wheel system configurations are first discussed in a general manner. Three of these systems which appear more promising than the others are analyzed in detail, using the Orbiting Astronomical Observatory as an example. The three systems differ from each other only by the method of damping, which is provided by either a rate gyro, an error-rate network, or a tachometer in series with a high-pass filter.

An analytical investigation which consists of a generalized linear analysis, a nonlinear analysis using the switching-time method, and an analog computer study shows that all three systems are theoretically capable of producing adequate response and also of maintaining the required pointing accuracy for the Orbiting Astronomical Observatory of ±0.1 second of arc. Practical considerations and an experimental investigation show, however, that the system which uses an error-rate network to provide damping is superior to the other two systems. The system which uses a rate gyro is shown to be inferior because the threshold level causes a significant amount of limit-cycle operation, and the system which uses a tachometer with a filter is shown to be inferior because a device with the required dynamic range of operation does not appear to be available. The experimental laboratory apparatus used to investigate the dynamic performance of the systems is described, and experimental results are included to show that under laboratory conditions with relatively large extraneous disturbances, a dynamic tracking error of less than ±0.5 second of arc was obtained.

From authors' summary by J. J. Adams, USA

5838. Bottema, O., The stability in precession of a symmetric gyroscope (in German), *Ing.-Arch.* **29,** 6, 425–427, 1960.

Let ϑ denote the angle of precession, $u = \cos\vartheta$, $V(u)$ the potential energy of the external force acting on the gyroscope, and P, Q the values of the derivatives dV/du, d^2V/du^2 for $\vartheta = \alpha$ ($\alpha \neq 0, \pi$), respectively. Then for any velocity of precession ω there is stability if $Q > 0$, or $Q = 0$, $P \neq 0$, or $Q < 0$, $P/Q > \sin^2(\alpha/2)$, or $Q < 0$, $P/Q < -\cos^2(\alpha/2)$. If, however, $Q < 0$ and $-\cos^2(\alpha/2) < P/Q < \sin^2(\alpha/2)$, there is stability only for $\omega^2 < \omega_1^2$ or $\omega^2 > \omega_2^2$, where ω_1^2 and ω_2^2 are the roots of the equation

$$A^2\omega^4 + A\,\omega^2(-2P\cos\alpha + Q\sin^2\alpha) + P^2 = 0.$$

Here A denotes the moment of inertia of the gyroscope about any axis which passes through the fixed point 0 and is perpendicular to the axis of symmetry of the gyroscope.

E. Leimanis, Canada

5839. Eide, D. G., Experimental evaluation of the deceleration of aluminum cylinders rotating in a magnetic field and comments on magnetic damping of a flywheel control, NASA TN D-749, 35 pp., Apr. 1961.

An experimental investigation has been made to determine the magnetic deceleration of a closed-end cylinder rotating in a magnetic field by use of opposed ball and socket air bearing support. The theories of Smythe and Hooper were compared with the experimental data for aluminum cylinders with fineness ratios of 9:1, 4:1, and 2:1 and a wall thickness of 0.254 centimeter and one cylinder with a fineness ratio of 6:1 and a wall thickness of 0.508 centimeter. A method is outlined by which the magnetic damping coefficient for the spinning motion of a body of revolution may be determined experimentally.

The theory of Smythe for a thin-walled cylinder predicts values greater than experimental results for fineness ratios of less than 6:1. Hooper's theory is in agreement with the experimental results throughout the range of fineness ratios tested.

A utilization of the magnetic damping to prevent overspeeding of a flywheel used in a satellite orientation system is discussed.

From author's summary

5840. Sakai, S., Theoretical analysis of the tup-motion of a forging air hammer, *Bull. JSME* **4,** 13, 66-76, Feb. 1961.

The equation of tup motion in an air forging hammer is difficult to solve—both its general and particular solution. Thus, the differential equation is replaced with an algebraic equation which is solved numerically for tup displacement, velocity and acceleration. This in turn permits selection of best crankshaft speed for each machine capacity. It permits a more efficient design at most economic power consumption.

Solution neglects tup rebounding phenomena, which depend upon elasticity of work material, assuming sufficient damping and therefore a short duration of rebound transients. Author points to close agreement between tup motion curves calculated by his method and those obtained experimentally by Keilholz in Germany. He further claims the controversial suggestion that the forging effect upon steel can be obtained by using a lead test piece.

J. P. Vidosic, USA

5841. Pozharitskii, G. K., On the equations of motion for systems with nonideal constraints, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **24,** 3, 669-676, 1960. (Pergamon Press, 122 E. 55th St., New York 22, N.Y.)

With nonideal constraints, the reactions of the constraints (due to elastic deformation) have to be taken into account. It is assumed here that the reactions are uniquely determined by the state of the system and the forces acting on it. It is shown that such a nonideal system is subject to certain relations (called "axioms of reaction"). The analysis can be applied to automatic control systems in which the control action can be interpreted as a constraint.

A. W. Babister, Scotland

5842. Shimanov, S. N., On the stability in the critical case of a zero root for systems with time lag, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **24,** 3, 653-668, 1960. (Pergamon Press, 122 E. 55th St., New York 22, N.Y.)

Krasovskii's method is used to replace the set of difference-differential equations by a set of ordinary differential equations with an operator type of right hand side. The properties of this linear operator are investigated and stability criteria are deduced. In the critical case, the stability depends upon the nature of the nonlinear perturbing forces. The method is explained by two examples.

A. W. Babister, Scotland

5843. Ruzicka, J. E., Analysis and design of tangent elasticity vibration isolators, *ASME Trans.* **83** B (*J. Engng. Industry*), 1, 53-60, Feb. 1961.

A vibrating system of one degree of freedom is investigated, whose restoring force-displacement diagram is described by

$$P(\delta) = 2(K_0 b_c/\pi) \tan(\pi\delta/2b_c)$$

hence it is said to be of "tangent elasticity." The actual stiffness K at deflection δ becomes

$$K = K_0 \cos^{-2}(\pi\delta/2b_c).$$

For such a system the natural frequency and deflection are determined as functions of the load. Design criteria for springs of various shapes are developed. The question is discussed of how the characteristic height b_c of a given spring is to be determined.

In the discussion of the paper, C. T. Molloy points out the difficulties arising from hysteresis for determining slopes of load-deflection curves.

K. Klotter, Germany

5844. Macinante, J. A., The optimum number of non-linear isolators for a seismic mounting, *Austral. J. Appl. Sci.* **12,** 1, 1-10, Mar. 1961.

A one-degree-of-freedom system is considered where identical nonlinear springs in parallel connect the mass to the ground. The springs support the weight of the single mass. The number of springs which give the minimum natural frequency for small oscillations about the equilibrium position is to be determined. Five different analytical expressions for the spring load-deflection characteristic are studied by (1) an exact, tedious method and (2) an approximate method. As one would expect, the results show that the springs must be sufficiently "hardening" before their number should be increased over that required from strength considerations.

P. R. Paslay, West Germany

5845. Bogusz, W., Application of the retract method in nonlinear engineering problems (in English), *Arch. Mech. Stos.* **12,** 4, 437-450, 1960.

Paper concerns topological method of investigation due to Wazewski [*Ann. Soc. Polon. Math.* **20**(1947)] of solutions of the system of ordinary differential equations

$$dx_i/dt = f_i(t, x_1, \ldots, x_n) \qquad (i = 1, \ldots, n).$$

By means of topological theorems, the behavior of solutions in the presence of singular points, or outside a singular point, can be examined. Specific applications are shown for a nonlinear dynamical system with negative elasticity, and for the differential equations for currents in an electrical circuit. In the former case, it is shown, for example, that the system $d^3x/dt^3 - k^2x + \alpha\, dx/dt + \beta(dx/dt)^3 = 0$ always has a bounded solution.

Left side of second equation of [2.3] should read "dx_2/dt."

M. Morduchow, USA

5846. Ury, J. F., The inverse problem with sinusoidal forcing of linear second-order systems, *J. Mech. Engng. Sci.* **3,** 1, 50-61, Mar. 1961.

Different methods, known in part from the literature, are reviewed, by which the inverse problem with sinusoidal forcing of linear second-order systems can be solved. Various geometrical relations are explained which may be used in plotting response curves with greater ease, speed, and accuracy. If response analysis has to be based on measurements of magnitude alone, integration of the magnitude-*versus*-frequency curve appears to form a

convenient and accurate means. The limitations of an analysis based on magnitude curves alone are discussed.

From author's summary

Instrumentation and Automatic Control

(See also Revs. 5832, 5837, 6357, 6434, 6442)

Book—5847. Beckwith, T. G., and Buck, N. L., Mechanical measurements, Reading, Mass., Addison-Wesley Publishing Co., Inc., 1961, xiv + 559 pp. $8.75.

This 540-page book breaks important ground in this field. Its title is slightly misleading as it deals with various methods of measuring those properties usually associated with mechanical engineering. It marks an important step in the treatment of these measurements as extensive coverage is given to determining and recording transient phenomena, whereas earlier writers usually treated only static phenomena.

The modern science of instrumentation and measurement has become too complex for one to expect a book that will give all details of how to "take" a particular measurement. Beckwith and Buck have wisely left this to the ASTM, ASME, and other societies.

Ample discussion is given of the philosophy of accurate and precise measurement, general sources of error, and the effects of various units in the chain from detector to modifier to display device. Coverage is not uniform, varying from one type of measurement to another, but this can hardly be avoided in a book of this type as it reflects the experience and interests of the authors. The treatment of the measurement of linear dimensions and strain does seem to be somewhat out of proportion.

These are details. In general, the worker in any field of measurement can profit greatly from its treatment of fundamentals. Workers in linear, strain, force, pressure, flow, temperature, and vibration will find it up-to-date and providing numerous helpful hints as well as offering a wide range of methods of attack.

C. E. Balleisen, USA

5848. Mal'chikov, S. V., On the syntheses of linear automatic control systems with variable parameters, *Automation and Remote Control* **20,** 12, 1543–1549, June 1960. (Translation of *Avtomatika i Telemekanika* **20,** 12, 1588–1594, Dec. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

This paper advances a straightforward method of synthesizing the weighting function of a compensation network for linear time-varying automatic control systems whose over-all "optimal" weighting function and the weighting function of fixed linear time-varying elements within the system are specified *apriori*. No indication is given as to how the over-all "optimal" weighting function of the system is determined. Three system configurations are considered: series and parallel open-loop connection between fixed and compensation elements and a feedback connection with the compensation anywhere within the closed loop.

The essence of the method by which the author obtains the optimal weighting function of the compensation network is to use what he terms "the concept of inverse elements," i.e. two elements are called inverse of each other if, when connected in series, they effect the identity transformation on any signal applied to the input to this connection. Elementary manipulations and transformations, all in the time domain, enable the weighting function of the compensation to be determined in closed form by direct integration or recursively by the method of successive approximations. The author points out that his technique circumvents the difficulties associated with having to solve Volterra integral equations of the first kind, which ordinarily would have to be dealt with in solving this problem.

Three examples, two of which are feedback systems, are presented to illustrate the author's method. No discussion as to constraints, such as physical realizability, on the synthesized compensation is given.

V. D. Norum, USA

5849. Schwarze, G., Continuous linear elements (in German), *Automatisierung: Z. Messen, Steuern, Regeln* **3,** 4, 151–153, Apr. 1960.

This short paper points out that continuous linear elements can be represented by a linear integral operator of the Stieltjes type.

P. G. Kirmser, USA

5850. Strejc, V., The general theory of autonomy and invariance of linear systems of control (in English), *Acta Techn., Nakladatelstvi Ceskoslovenske Akad.* **5,** 3, 235–258, 1960.

It is shown that if the numerator and denominator matrices of the transfer function between a vector of controlling variables and one of response variables are sums of products of a controlled and a controlling matrix, then it is possible to choose the controlling elements so that the product matrices are diagonal. A transfer function which is a ratio of diagonal matrices represents a decoupled (autonomous) system. The form of transfer function for which the output is unaffected by (invariant to) a given input variable is also described. Realizability of matrix elements is not discussed. A list of references to world literature is given.

C. M. Ablow, USA

Book—5851. Bedel'baev, A. K., Stability of nonlinear automatic control systems [Ustoichivost'nelineinykh sistem avtomaticheskogo regulirovaniya], Alma-Ata, Izadel'stvo Akad. Nauk KazSSR, 1960, 163 pp. 7 r. (Paperbound)

Book, based on lectures, brings no original results but a nicely written introduction to the methods and results found in particular by Lur'e, Letov and Malkin and published in various books and papers.

After a short survey on the theory of control systems and on the basic theorems of stability and Lyapunov's second method, author considers systems of the form

$$\dot{\eta}_s = \sum_k b_{sk}\eta_k + n_s\xi, \quad \dot{\xi} = f(\sigma), \quad \sigma = \sum_s f_s\eta_s - r\,\xi$$

which are well known from numerous Soviet papers. He deals with the following problems: canonical transformations of the equations, stability criteria of Lur'e, Letov, Malkin and their modifications, "essentially unstable" systems, dangerous and nondangerous segments of the border of stability. Each section is illustrated by some examples, but, as usual, these examples are treated from the purely mathematical point of view without even mentioning the concrete technical problems in the background.

W. Hahn, Germany

5852. Gille, J.-C., and Wegrzyn, S., A sufficient condition for the stability of nonlinear feedback systems (in French), *Automatisme* **6,** 3, 89–93, Mar. 1961.

A method is described for studying the global stability of certain nonlinear systems, starting from the study, which is usually easy, of the stability of an "associated" linear system. In the cases treated this leads to a sufficient condition for global stability which is very simple in principle and application. The proposed method is compared, by means of examples, with the method of "first harmonic approximation" and with Lyapunov's direct method.

Translated from the authors' summary by H. D. Block, USA

5853. Whitbeck, R. F., Phase plan analysis, the application of Lienard's construction to a particularly important second order nonlinear differential equation, *Information and Control* **4,** 1, 30–47, Mar. 1961.

The second-order nonlinear differential equation of the form $\ddot{x} + f(x)\dot{x} + g(x)x = 0$ is studied. In order to reduce this differential equation to a form to which Lienard's method can be applied, i.e., $\ddot{x} + \phi(\dot{x}) + x = 0$, two changes of variable are applied. The method introduced in this paper requires no step-by-step numerical computation. Paper includes the following chapters: 1. Lienard's construction, 2. The necessary transformations, 3. Application to a Type I servo, 4. Comparison with "Delta" method (a graphic-numerical method introduced by Buland).

O. Gurel, USA

5854. Oldenburger, R., Nicklas, J. C., and Gamble, E. H., Optimum nonlinear control of a second order nonlinear system, NASA TN D-825, 89 pp., Apr. 1961.

A design technique of R. Oldenburger for the optimum nonlinear or predictor control of linear systems is herein extended to such control of a nonlinear system. This nonlinear system is composed of two major sub-systems—a nonlinear controlled plant and a controller where the system output is that of the controlled plant.

From authors' summary by H. D. Block, USA

5855. Neimark, Yu. I., and Shil'nikov, L. P., On the application of the method of a small parameter to systems of differential equations with discontinuous right-hand sides (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 6, 51–59, Nov./Dec. 1959.

Poincaré's method for finding periodic solutions of nonlinear systems was generalized to the nonanalytic case by I. G. Malkin ["Some problems of the theory of nonlinear oscillations," State Tech. Press, 1956 (in Russian)]. The author uses a fixed-point theorem to extend Malkin's scheme to a still wider class of nonanalytic systems: the case where, for $\dot{x} = F$, F and its derivatives are allowed to have jump discontinuities on a sufficiently smooth surface. The case of a quasilinear system is considered in detail.

N. D. Kazarinoff, USA

5856. Arai, T. T., and Madigan, J. R., Response of a thermocouple circuit to nonsteady currents, *J. Appl. Phys.* **32,** 4, 609–616, Apr. 1961.

It has been shown theoretically that it is not possible to obtain greater temperature differences between the hot and cold junctions by initially applying currents greater than the optimum steady-state currents. By experimentation it is possible to momentarily obtain greater temperature differences by superposing a time-varying current upon the optimum direct current. This investigation is a study designed to investigate quantitatively the effect of time-varying currents on the transient response of the couple based on simplifying assumptions.

G. A. Hawkins, USA

5857. Gordon, B. M., and Seaver, W. H., Designing sampled-data systems, *Control Engng.* **8,** 4, 127–132, Apr. 1961.

Sampled-data-system theory is applied to derive keypoints in engineering synthesis of data-sampling and recovery systems. Filter, sampling aperture and sampling rate selection must be made on the basis of signal frequency with engineering compromise. Principles are explained clearly using examples and figures.

Y. Takahashi, USA

5858. Flügge-Lotz, I., and Yin, M., The optimum response of second-order, velocity-controlled systems with contactor control, *ASME Trans.* **83** D (*J. Basic Engng.*), 1, 59–64, Mar. 1961.

This paper is concerned with the optimum control problem for plants described by second-order differential equations with constant coefficients and with velocity control. Emphasis is placed on the case where the characteristic equation of the system has one zero root and two complex conjugate roots. The problem is studied in terms of the motion of the phase point in a three-dimensional phase space. An iteration method is developed to obtain the optimum trajectory, which in turn gives the optimum response.

From authors' summary by S. Z. Dushkes, USA

5859. Tartakovskii, G. P., Application of simulation in analyzing linear pulse systems with variable parameters, *Automation and Remote Control* **20,** 5, 559–566, Feb. 1960. (Translation of *Avtomatika i Telemekanika USSR* **20,** 5, 583–590, May 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

Any linear servo-system can be characterized by its impulse response function $b(t,\tau)$ which is the response at the time t for a unit impulse applied at time τ. For a time-invariant system, $b(t,\tau)$ reduces to a function of one independent variable $t - \tau$. Straightforward simulation of a servo-system gives $b(t,\tau)$ as a function of t with τ fixed for each simulation run. In many cases, for instance when calculating the output correlation function with a given input correlation function, $b(t,\tau)$ is desired as a function of τ with t fixed. For the time-invariant systems this is trivial but for a time-variable system the conjugate system has to be simulated instead of the original system. This holds for both continuous and pulsed systems as is shown in the paper. In particular, author considers a pulsed system consisting of a second-order continuous portion and a time-variable forward loop gain.

F. Y. Hjelte, Sweden

5860. Minagawa, S., A simplified technique of estimating steady state performance of on-off control systems, *Mem. Fac. Engng., Univ. Nagoya* **11,** 1/2, 153–159, Nov. 1959.

A phase plane method to determine limit cycle pattern for symmetrical bang-bang controls is presented. Trajectory equation involves error e, error rate $\dot{e}$, and starting point e_0, $\dot{e}_0$. Substituting e_0 and $\dot{e}_0$ in trajectory equation by $-e$ and $-\dot{e}$, virtual switching-line equation is derived. Intersections of virtual switching line and switching line give limit cycle condition. Examples treated include bang-bang controls triggered by nonlinear function of error and error rate, with or without hysteresis.

Y. Takahashi, USA

5861. Tsypkin, Ya. Z., On optimum processes in pulsed automatic systems, *Soviet Phys.-Doklady* **5,** 5, 929–931, Mar./Apr. 1961. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **134,** 2, 308–310, Sept. 1960 by Amer. Inst. Phys., Inc., New York, N.Y.)

5862. Stallard, D. V., Preliminary design of a roll-stabilization system for a ship, *ASME Trans.* **83** D (*J. Basic Engng.*), 1, 125–131, Mar. 1961.

Author treats analytical problem of stabilizing a ship against roll by the use of a pair of servo-controlled fins, which respond to a signal from a roll sensing device such as a gyroscope. Roll stabilization is a subject which has been extensively covered in the literature and many successful systems are in use on passenger vessels. Preliminary design of a roll damping system, employing a damped pendulum and a rate gyro, is worked out for a particular passenger vessel with low inherent damping. Alternative designs of valve-controlled and pump-controlled fin servomechanisms are considered and it is shown that the latter type is more efficient from the standpoint of power consumption, although this advantage is offset somewhat by higher equipment cost and complexity.

S. Z. Dushkes, USA

Book—5863. McClure, C. L., Theory of inertial guidance, Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1960, xi + 340 pp. $12.00.

The object of this book is to provide a self-contained introduction to the theory of inertial guidance. The book may be divided into three main sections. The first, an introduction, deals with elementary facts concerning the figure and motion of the Earth and with basic concepts of navigation. The second section, Chapters 2–6, is a development of rigid-body kinematics and kinetics, with special emphasis on gyroscopic motion. The third part, Chapters 7–10, treats guidance systems as such.

It is this reviewer's opinion that the treatment falls so far short of the stated goal that the book cannot be taken seriously as a technical work. Both the choice of topics and the details of the exposition are open to major objections. For instance, in the third section of the book the problem of azimuth control, including gyrocompass effects, is barely mentioned. No reference is made to modern developments in gyro technology, e.g., the magnetically supported free gyro, and their probable effects upon inertial guidance systems of the future. The physical significance of many of the results are presented obscurely if at all. A few topics which may be difficult to find elsewhere are treated adequately, notably the anisoelastic drift of single-degree-of-freedom gyros and velocity damping. However, the beginner would gain much less from reading the third section of this book than from a careful study of a paper such as "Principles of inertial guidance," by Draper, Wrigley and Woodbury [AMR **13**(1960), Rev. 4445].

The reviewer finds the section on dynamics and the introduction to be entirely unsatisfactory. The errors of fact and interpretation which occur are sometimes monumental. We "learn" in the introduction that the precession of the equinoxes is caused by a motion of the solar system relative to neighboring stars. Later, in the proofs of the principles of motion of the mass center and of angular momentum of systems of particles, the author misses the point by failing to distinguish between internal and external forces.

However, not even the above errors are as deplorable as the uniformly bad style of presentation. Clarity is not served by the use of phrases such as "the angular velocity of the point," or "the force reacted by the mass point." Moreover, the author's tortured and stilted prose is nothing less than an assault upon the English language. As a result, the exposition is usually unclear and often unintelligible. A. Robinson, USA

5864. Foudriat, E. C., Study of the use of a terminal controller technique for reentry guidance of a capsule-type vehicle, NASA TN D-828, 29 pp., May 1961.

Author proposes to use a terminal controller technique in the guidance of a capsule-type reentry vehicle to a desired landing point. Linear two-degree-of-freedom equations are used to describe the vehicle dynamics. These equations are attained by the perturbation of the dependent variables from those of a reference trajectory. The guidance system continuously predicts the final error in the range travelled and uses this error to control the angle of attack of the vehicle. The terminal guidance technique requires that the flight time of the vehicle in order to attain the desired range be known. The results indicate control to within $\pm 0.1^\circ$ in range over the total range capability of the vehicle and a minimum number of control corrections in an on-off manner. K. Magnus, Germany

5865. Lee, S.-Y., Improvement of the power efficiency of a hydraulic control system by the use of a gain compensated control valve, *ASME Trans.* **83** D (*J. Basic Engng.*), 1, 119–124, Mar. 1961.

A conventional control valve in a valve-controlled hydraulic system is of the area-controlled type, that is, the orifice area of the valve is a function of the input signal to the valve. Since the flow through the valve depends also on the load pressure drop and supply pressure, the gain of such a valve is not constant. The author proceeds to demonstrate that this control arrangement is not optimum either from the power efficiency or performance standpoint. By using flow feedback it is possible to achieve a constant gain control valve and thereby satisfy the stability requirement at low loads and the dynamic response requirement at high loads.

Author discusses the load forces acting on the actuator of a position control system and lists the parameters used to specify the performance of the system. He then proceeds to outline a step-by-step trial and error procedure for designing a system. Finally, the author shows why it is possible to achieve a higher efficiency with the flow feedback valve than with the area-controlled valve. S. Z. Dushkes, USA

5866. Glaettli, H. H., Hydraulic logic: What's its potential, *Control Engng.* **8,** 5, 83–86, May 1961.

5867. Dmitriev, V. N., and Chernyshev, V. I., Calculation of time characteristics of pneumatic flow chambers, *Automation and Remote Control* **19,** 12, 1087–1095, June 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19,** 12, 1118–1125, Dec. 1958 by Instrument Society of America, Pittsburgh 22, Pa.)

An analysis is made of flow through a pneumatic chamber containing two orifices. Subcritical and supercritical pressure ratios for each orifice are considered. Curves are presented to facilitate steady-state and transient calculations. Sample calculations for several combinations of orifice pressures are carried out in a pneumatic relay with throttling. H. M. Spivack, USA

5868. Slater, J. M., Autocompensation of errors in gyros and accelerometers, *Control Engng.* **8,** 5, 121–122, May 1961.

5869. Krochmann, E., Data handling by computers and utilization of the resultant information in control loops (in German), *Regelungstech.* **9,** 4, 137–143, Apr. 1961.

Elasticity

(See also Revs. 5810, 5813, 5815, 5827, 5834, 5840, 5851, 5904, 5905, 5915, 5922, 5927, 5928, 5938, 5954, 5963, 5964, 5965, 5966, 5989, 6014, 6018, 6049, 6050, 6052, 6099, 6113, 6119, 6268, 6443)

5870. Naghdi, P. M., and Hsu, C. S., On a representation of displacements in linear elasticity in terms of three stress functions, *J. Math. Mech.* **10,** 2, 233–245, Mar. 1961.

Paper is concerned with a new representation in terms of three stress functions of the general solution of the equation satisfied by the displacement vector in infinitesimal isotropic elasticity theory. It is proved that the displacement vector can be expressed in terms of a vector function ψ and a scalar function which is uniquely determined in terms of ψ. The relationship between this representation and earlier ones in terms of four stress functions, e.g. the Boussinesq-Papkovich representation, is established. R. Tiffen, England

5871. Golecki, J., Displacement functions for an isotropic incompressible elastic solid (in English), *Bull. Acad. Polonaise Sci., Ser. Sci. Tech.* **7,** 4, 265–271, 1959.

Author states paper is concerned with statics of an isotropic, linearly elastic incompressible body which constitutes the particular case in classical elastic theory for which Poisson's ratio = 0.5. From previous work it was concluded that a separate treatment

was necessary and a detailed analysis would permit use of a new model to explain deformation processes of a real body where volume changes are negligible, act as a basis for approximate solutions in elastic theory particularly for values of Poisson's ratio approaching 0.5, and contribute to formulation of the theory of elastic-plastic deformation of an incompressible body. Paper is wholly mathematical and, since there is no table of notation, hard to follow. Five references are given which seem essential adjuncts to obtaining a clear understanding, and a sixth reference cited in a footnote is not listed.

A. F. W. Langford, Australia

Book—5872. Novozhilov, V. V., The theory of elasticity [**Teorya upsrugosti**], Leningrad, Sudpromgiz, 1958, 370 pp. + illus. 13 r 10 k; *Ref. Zb. Mekh.* no. 11, 1959, Rev. 13856.

The author, realizing the importance in technical practice of the solution of nonlinear problems, sets out the objective of his book as "the exposition of the theory of elasticity in a form which will enable an investigation to be made of all its problems from a single point of view without giving preference to any determined, simplified variant of the theory." The first five chapters, comprising the larger part of the contents of the book, deal with general questions in the theory of elasticity. In this part will be found appreciably developed and supplemented material which originally appeared in the well-known book by the author "The bases of the nonlinear theory of elasticity," (L.-M., Gostekhizdat, 1948). The additional material refers not only to purely methodical questions but to the latest results in the field of the nonlinear theory of elasticity, including work done by the author himself. Special attention is given to the classical results obtained in the linear theory of elasticity; the fifth chapter is devoted in its entirety to them. The equations in this chapter are obtained as a particular case by the discarding of the nonlinear terms in the formulas for the components of deformation and in the equations for the equilibrium and the utilization of Hooke's principle. At this point expositions are also given on the general solution of the questions in the theory of elasticity in the form evolved by P. F.Papkovich, on the theory of thermal stresses, the theorems of actuality and uniqueness, the equations for the anisotropic theory of elasticity, and so forth. The last two chapters deal with the solutions of concrete questions (the Saint-Venant problem, the plane problem); however reference here is restricted to linear problems. The clarity of exposition gives a combined picture of modern problems in the theory of elasticity, to which the book is dedicated, which will make it available to a wide circle of readers. The chapter headings are as follows: 1. The theory of deformations. 2. The equilibrium of the volumetric element. 3. The work of deformation and some principles connected therewith. The stress potential of an ideal elastic body and the correlations resulting therefrom between the stresses and the deformations. 4. Curvolinear coordinates. 5. The general formulae of the classical (linear) theory of elasticity. 6. The Saint-Venant problem. 7. The plane problem in the theory of elasticity.

G. S. Schapiro

Courtesy Referativnyi Zburnal, USSR

5873. Signorini, A., Problems in nonlinear elasticity (in Italian), *R. C. Mat. Appl. Univ. Roma* **19**, 1/2, 1–71, 1960.

In these lectures the author continues [see AMR **14**(1961), Rev. 1217] the exposition of some of his results in the field of hyperelasticity. Here he considers finite deformations of bodies which are incompressible at constant temperature [see also *Ann. Mat. Pura Appl. (4)* **39**(1955), 147–201]. In an introduction he derives first some classical results: for instance Piola's equations of equilibrium of continua in terms either of the Piola-Kirchhoff stress double vector or of the Piola-Cosserat stress tensor. Then he considers the role of thermodynamic principles in the analysis of properties of the elastic potential. Finally he deals with some of his contributions to the theory. For instance: an extension of Almansi's formulas [which express the principal components of Cauchy's stress tensor in terms of the principal stretches; see also *R. C. Accad. Lincei (8)* **24**(1958), 246–253]; a formula which gives Cauchy's stress tensor in terms of the strain tensor of the inverse displacement only (so that the local rotation is not involved); and the following theorem: within the field of isothermal statics, in problems where the stresses are specified at the boundaries, the displacement is generally determined apart from a translation (and there is a sharp contrast here with the linear theory, according to which a rigid rotation is also allowed).

For readers who are more concerned with special applications than with general principles the last part of the paper is of greatest interest. Here the author considers some aspects of a hyperelastic theory of second degree which he proposed over twenty years ago and which is based (on general principles) on the sole assumption that the components of Cauchy's stress tensor are functions of second degree of the components of strain for the inverse displacement. For an incompressible medium the assumption leads to a form of the elastic potential which is slightly more general than that proposed by Mooney and Rivlin. This result adds to the interest of the theory, many consequences of which the author had tested already [see *Ann. Mat. Pura Appl. (4)* **30**(1949), 1–72].

G. Capriz, England

5874. Teodorescu, P. P., Application of elementary computational method to three-dimensional elasticity problems (in German), *Rev. Mècan. Appl.* **5**, 5, 649–667, 1960.

A general formula for generating biharmonic polynomials is given. It is shown how a unified presentation of the solutions to certain elementary problems is possible by using biharmonic polynominals in conjunction with a general solution in terms of three biharmonic functions. In the same way, an exact solution for a thick rectangular plate under uniform lateral pressure with certain elastic supports is given which contributes to an understanding of the nature of the approximation in the usual plate-bending equation.

E. H. Dill, USA

5875. Belen'kii, M. Ia., Some axially symmetric problems of elasticity theory, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **24**, 3, 868–873, 1960. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Integral transforms are given whereby the axially symmetric three-dimensional elasticity problem can be reduced to the solution of an auxiliary problem in plane stress. The solution procedure is indicated for the axisymmetric problem of a region lying between the planes $z = \pm 1$ and loaded only on the edges $r = r(\theta)$ by given stresses which are independent of z.

E. H. Dill, USA

5876. Bramble, J. H., A sphere theorem for the equations of elasticity (in English), *ZAMP* **12**, 1, 1–6, Jan. 1961.

Article concerns the problem of an infinite isotropic elastic solid bounded internally by a spherical elastically supported boundary, for which the free and fixed boundaries are special cases. The components of displacement and stress are treated in rectangular coordinates and, because of the symmetry of the sphere, the three components of the displacement vector are given as a single indexed quantity.

H. D. Conway, USA

5877. John, F., Plane strain problems for a perfectly elastic material of harmonic type, *Comm. Pure Appl. Math.* **13**, 2, 239–296, May 1960.

Paper is concerned with finite, plane strain deformation of a material with a particular kind of strain energy function. The positional coordinates, $u(x,y)$, $v(x,y)$, of particles in the strained

state are taken as independent variables and the strain energy density W is considered as a function of the two arguments $r = [(u_x + v_y)^2 + (v_x - u_y)^2]^{1/2}$, $s = u_x v_y - u_y v_x$. The material is defined as "harmonic" when $W(r,s) = 2\mu [F(r) - s]$; equilibrium problems in this medium may be discussed as a type of potential problem. The equations of motion are hyperbolic for $F'(r) > 0$ only, and other cases are not considered in detail. A *proper* solution is defined as requiring u and v to have bounded Dirichlet integrals over the bounded simply-connected region occupied by the medium, and the existence of such solutions under two kinds of boundary conditions is proved. For prescribed boundary displacement, uniqueness is proved. The second problem concerns a quadrilateral with two opposite sides straight and parallel, the other two arbitrarily curved and traction-free. The straight sides are brought closer together, remaining parallel and shear-free. Buckling, which is fully discussed, may exclude a unique solution.

Mathematically this paper is very interesting, but its physical interest depends on whether real materials are to be found with a W of the right form, or approximating to it.

D. S. Berry, England

5878. Szolagowski, F., Contribution to the solution of the plane problem of elasticity theory in functions of a complex variable (in English), *Bull. Acad. Polonaise Sci., Ser. Sci. Tech.* **8,** 10, 565-567, 1960.

Paper gives brief reformulation of equations relating stress in a semi-infinite plate to applied boundary loadings, in terms of complex stress functions. C. E. Turner, England

5879. Manacorda, T., Thermoelasticity of incompressible solids (in Italian), *Riv. Mat. Parma* (2), **1,** 149-170, 1960.

By using linearized transformations, author establishes some general results for incompressible solids. General equations are given both for the unsteady and steady cases. Representations of the solutions of Papkovitch-Neuber type and applications of these results are given. P. P. Teodorescu, Roumania

5880. Podstrigach, Ya. S., and Chaevskii, M. I., On thermal stresses caused by internal energy dissipation and their influence on fatigue strength of machine parts (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 97-102, Jan./Feb. 1959.

5881. Gatewood, B. E., Grothouse, A. P., and Von Hausen, W. W., Experimental data on strain accumulation under equivalent thermal cycling, *J. Aerospace Sci.* **28,** 6, 502-503 (Readers' Forum), June 1961.

5882. Nemirovskii, Yu. V., Stresses in nonuniformly heated disks beyond the elastic limit (in Russian), *Zh. Prikl. Mekh. Tekh. Fiz.* **1,** 122-124, May/June 1960.

5883. Lomakin, V. A., A problem of thermal stresses in elastic-plastic media (in Russian), *Inzbener. Sbornik Akad. Nauk SSSR* **25,** 174-178, 1959.

5884. Besseling, J. F., A theory of small deformations of solid bodies, AFOSR TN 59-605 (Stanford Univ., Dept. Aero. Engng., SUDAER no. 84; ASTIA AD 217 172), 104 pp., Feb. 1959.

Author presents a complete thermodynamic theory of small deformations of solid bodies, the mathematical description of all important phenomena observed in the deformation and heating of solid bodies. He presents means by which the relevant equations can be solved approximately or exactly. He uses the entropy displacement field introduced by Biot, but his theory deviates in many respects from the work of Biot. Author deduces the basic relations of thermoelasticity, and creep and plasticity. He applies the variational principles to solve several problems. As an example he investigates the thermoelastic damping of a prismatic beam performing pure bending vibrations and the creep damping of a hollow shaft subjected to torsional vibrations.

Numerous references are given.

S. Sarkadi Szabo, Hungary

5885. Teodorescu, P. P., On the plane problem of elasticity of some aeolotropic bodies (in English), *Rev. Mĕcan. Appl.* **5,** 3, 385-399, 1960.

Author states paper is a synthesis of a number of works previously published in Roumanian. General Hookean-type elastic laws for aeolotropic bodies are stated, particular attention being given to the orthotropic case, for both plane stress and plane strain. Governing stress-function-type equations are derived for these cases by combining the compatibility equations with the equilibrium equations in the usual manner.

Terms for body force, inertia and damping force are included in the equations of equilibrium, and temperature difference, in the orthotropic elastic laws used.

The resulting equations are not applied to any particular problem in the present paper. A list of over fifty references is given, mainly relating to foreign language publications.

C. E. Turner, England

5886. Stojanovitch, R., On the stress-strain relations for nonhomogeneous isotropic elastic solids (in English), *Arch. Mech. Stos.* **12,** 3, 281-285, 1960.

In previous work the author developed a geometric derivation of nonlinear stress-strain relations for isotropic elastic solids. In this paper he extends the work to the case of isotropic but nonhomogeneous solids. His final result is a set of equations which are the modified Lame equations of equilibrium for infinitesimal deformations of isotropic nonhomogeneous solids.

A. G. H. Dietz, USA

5887. Collins, D., On the stress distribution due to force nuclei in an elastic solid bounded internally by a spherical hollow, and in an elastic sphere (in English), *ZAMP* **11,** 1, 3-16, 1960.

Expressions are given for the stresses caused by force nuclei in an infinite elastic solid; by superimposing a second stress system the radial and shearing stresses are eliminated on the surface of a sphere. Formulas are given for the distribution of the non-zero stress components on the surface of this sphere; numerical values are tabulated for several values of the distance of the force nucleus from the center of the sphere and for two values (0.2 and 0.4) of Poisson's ratio.

Similar formulas and numerical values are given for an elastic sphere that is stressed by two symmetrically placed internal nuclei. G. Sved, S. Australia

5888. Eshelby, J. D., The elastic field outside an ellipsoidal inclusion, *Proc. Roy. Soc. Lond.* (*A*) **252,** 561-569, Oct. 1959.

The elastic field outside an inclusion or inhomogeneity is treated in detail. For a general inclusion the harmonic potential of a certain surface distribution may be used in place of the biharmonic potential used in an earlier paper. The elastic field outside an ellipsoidal inclusion or inhomogeneity may be expressed entirely in terms of the harmonic potential of a solid ellipsoid. The solution gives incidentally the velocity field about an ellipsoid which is deforming homogeneously in a viscous fluid. An expression given previously for the strain energy of an ellipsoidal region which has undergone a shear transformation is generalized to the case where the region has elastic constants different from

those of its surroundings. The Appendix outlines a general method of calculating biharmonic potentials.

J. D. Marketos, USA

5889. Sobolev, Yu. S., The plane problem in the theory of elasticity for wood viewed as a transversally-isotropic material (in Russian), *Nauchn. Trudi Mosk. Lesotekhn. In-ta* no. 8, 5–15, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13995.

Two particular cases are solved; the problem of the stresses in a wooden cantilever beam loaded by a triangular load is solved with the aid of polynomes for the case where the axis of the beam coincides with the direction of the wood's fibers; if the length of the beam is four times or more in excess of its height then the stresses differ from those calculated by the elementary theory of bending by not more than 17.3%. The second problem—the compression of a high rectangular plate—is solved with the aid of Fourier series. A comparison is made with the solution for an isotropic material [S. P. Timoshenko, "The theory of elasticity," Leningrad-Moscow, Gostekhteorizdat, 1934]. Irregularity in the distribution of stresses on the sections of the plate is more marked when compression is along the fibers and less marked when across the fibers than is the case in isotropic material.

E. K. Ashkenazi
Courtesy Referativnyi Zhurnal, USSR

5890. Hashin, Z., The elastic moduli of heterogeneous materials, Harvard Univ., Div. Engng. Appl. Phys. Tech. Rep. 9 (Contract Nonr 1866(02)), 50 pp., Sept. 1960.

Analyzing the change in strain energy in a loaded homogeneous body, due to the inclusion of a uniform volume concentration of particles of another material, general expressions for the elastic moduli of a quasi-homogeneous heterogeneous material are developed in terms of the elastic characteristics of both the matrix material and the inclusions.

By a suitable choice of admissible stress and displacement fields and making the further assumption, as in small concentration theory, that the particles are spherical and each is entirely surrounded by a spherical shell lying wholly inside the matrix, expressions for upper and lower bounds of the bulk and shear moduli of the heterogeneous material are obtained.

Approximate formulas for the elastic moduli, valid whenever the bounds are close together, are also derived, and a comparison of the values thus obtained with experimental results for tungsten-carbide-cobalt alloys of various concentrations shows striking agreement.

E. Saleme, Argentina

5891. Dzhanelidze, G. Yu, The Saint Venant principle (in Russian), *Trudi Leningrad Politekhn. In-ta* no. 192, 7-20, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13831.

An historical survey is given of the genesis and future development of the Saint-Venant principle, the most important principle in the theory of elasticity; a review is furnished of the modern trend and contents of studies dealing with the more precise formulation of the principle and their proofs. The energetic proofs of Southwell are referred to [R. Southwell, *Phil. Mag.* **45,** 193–212, 1923] and also Zanaboni's [O. Zanaboni, *Atti Accad. Lincei, Roma* **25,** 118-121, 595, 1937]; the more general and extended formulation of the principle proposed by Mises [R. Mises, *Bull. Amer. Math. Soc.* **51,** 555-562, 1945] is dwelt on; it indicates the order of damping of the stresses with increase in the distance from the place of application of balanced and unbalanced loads; a strict interpretation of the proofs for Mises' attitude given by Sternberg is referred to [E. Sternberg, *Quart. Appl. Math.* **11,** 4, 393–402, 1954]. In conclusion some concepts are developed on the question of the applicability of the Saint-Venant principle to the dynamic problems put by Boley [B. Boley, *J. Appl. Mech.* **22,** 2, 204–206, 1955].

M. M. Filonenko-Borodich
Courtesy Referativnyi Zhurnal, USSR

5892. Tirskii, G. A., Torsion of a hollow shaft, bounded by wing profiles of Zhukovskii-Chaplygin (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 2, 114-121, 1959.

5893. Umanskii, E. S., Kvitka, O. L., and Agarov, V. A., The method of initial functions in the axisymmetrical problem of the theory of elasticity (in Ukrainian), *Dop. Akad. Nauk URSR* no. 11, 1167-1171, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13834.

A presentation is given of the solution of the axisymmetrical problem of the theory of elasticity and also of the problem of torsion by the method of initial functions due to V. Z. Vlasov [*Izv. Akad. Nauk, Otd. Tekh. Nauk* no. 7, 49-69, 1955]. The initial functions are determined on the surface of a round cylinder $r = r_0$. The components of transposition and stresses in the case of elastic equilibrium are expressed through the initial functions and their derivatives by steps of the axial coordinate Z in the form of an infinite series by steps $r = r_0$.

V. V. Vlasov
Courtesy Referativnyi Zhurnal, USSR

5894. Blokh, V. I., On torsion of elastic parobolic prisms (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 2, 166–169, 1959.

5895. Dovnorovich, V. I., Some contact problems regarding a solid die with a surface of rotation for an elastic semispace (in Russian), *Uch. Zap. Belorussk. In-ta Inzh. Zh.-d. Transp.* no. 2, 6–18, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13842.

The problem is investigated on the symmetrical pressure by a force, parallel to an axis z, friction forces not being present, acting on the elastic semispace of a smooth solid die with a surface described by the equation

$$z = \varphi(x,y) = A\,(x^2 + y^2)^{k+1} \qquad [1]$$

In this case the area of contact is round and in order to determine the pressure under the die the author makes use of L. A. Galin's formula [*Prikl. Mat. Mekh.* **10,** no. 4, 1946]

$$\sigma_z = -\frac{mG}{\pi\,(m-1)}\,\psi\,(x,y,0)$$

where

$$\psi\,(x,y,z) = \frac{1}{\pi}\int_S\int \frac{\Delta\varphi\,(x1,y1)}{r}\,\operatorname{arctg}\,\theta\,dx_1\,dy_1 \qquad [2]$$

$$\theta = \frac{\sqrt{a^2 - q_1^2}\,\sqrt{a^2 - x^2 - y^2 - z^2 + \sqrt{(a^2 - x^2 - y^2 - z^2)^2 + 4\,a^2 z^2}}}{a\sqrt{2}\,\sqrt{(x - x_1)^2 + (y - y_1)^2 + z^2}}$$

which is true when the pressure under the die is nowhere transformed into infinity. The outstanding part of the study is the method of analysis employed for the calculation of the integral [2] for the particular case when function $\varphi\,(x,y)$ is presented in the form of [1]. As an example the pressure is computed for the sole of the die the surface of which is assigned in the form of

$$\varphi\,(x,y) = \frac{63^3 A}{256}\,(x^2 + y^2)^3$$

V. I. Mossakovskii
Courtesy Referativnyi Zhurnal, USSR

Viscoelasticity

(See also Revs. 5950, 6026, 6071, 6075, 6078)

5896. Colonnetti, G., The interpretation of plastic deformations as heredity phenomena, Problems of continuum mechanics (Volume dedicated to N. I. Muskhelishvili on his 70th birthday), Philadelphia, Soc. Industr. and Appl. Math., 1961, 80–92.

Author states that no all-embracing mathematical theory has ever been conceived covering the irreversible phenomena known as hysteresis, plasticity, relaxation and creep in natural bodies and that one must abandon in such a theory the concept of a bi-univocal correspondence between stresses and elasto-plastic (permanent) strains. The deformation at any moment is no longer only a function of the present values of the stresses, but must be considered as dependent on their values during the past. It has become necessary to resort to distinguishing along the ideas expressed by *E. Picard* (1907) and *Vito Volterra* (1887, 1910) between the non-hereditary and the hereditary phenomena, the former being according to Volterra solvable by differential; however, the latter by the study of integrodifferential equations of the elliptic type, without first particularizing the functions that characterize the latter. According to author—when one deals with hereditary questions—it is useful to leave undetermined the functions which characterize the hereditary phenomena in general and to assign to their constant parameters values later based on the direct observations, in a process of computation that *V. Volterra* termed as the evaluation of *linear heredity*. If T denotes instant, given time, and if the total small strain is considered equal to the sum of two terms, the elastic, reversible strain ε (which is by definition a linear function of the state of stress) and the permanent, plastic strain, denoted by $\bar{\varepsilon}(T)$, this latter at current time T may be assumed in form of the definite integral:

$$\bar{\varepsilon}(T) = \int_0^T \alpha(t) \cdot f(T,t)\,dt$$

where the function $f(T,t)$ represents what *Volterra* has called the "coefficient of heredity" and the function $\alpha(t)$ the determining function "of the plastic deformation."

The paper considers a number of specific examples by assuming reasonably chosen forms for α and f, such as

$$\alpha = ct,\ f = a_1 + a_2 ct + a_3 c^2 t^2 + \ldots,\ c,\ a_1,\ a_2, \ldots$$

are material constants, permitting to express the plastic strain in form of a finite series:

$$\bar{\varepsilon}(T) = a_1 c\,\frac{T^2}{2} + a_2 c^2\,\frac{T^3}{3} + \ldots.$$

We shall not delve into reviewing the details of the discussion of practical examples taken from the theory of anelastic aftereffects in steel wires, bars of reinforced concrete, bent beams, disclosing in the latter what engineers called "residual stresses" after unloading. Work on similar problems is being done at the Instituto Dinamometrico of Turin. A. Nadai, USA

5897. Ivlev, D. D., On the theory of transient creep, Problems of continuum mechanics (Volume dedicated to N. I. Muskhelishvili on his 70th birthday), Philadelphia, Soc. Industr. and Appl. Math., 1961, 198–201.

A recent plasticity theory [AMR 12(1959), Rev. 3799] based on the effects of residual micro-stresses is extended to include viscous behavior. Using a two-dimensional model, complex stress-strain relations are derived "...only to demonstrate the possibility which exists in creep theory for the utilization of the concepts of micro-stresses." L. Mordfin, USA

5898. Odqvist, F. K. G., A non-linear eigenvalue problem in the theory of creep, Problems of continuum mechanics (Volume dedicated to N. I. Muskhelishvili on his 70th birthday), Philadelphia, Soc. Industr. and Appl. Math., 1961, 306–310.

The creep of a circular membrane under constant lateral pressure is analyzed by neglecting elastic and primary creep deformations and by assuming a specific stress versus strain-rate relation which incorporates two material constants. A system of differential equations is obtained which is solved numerically with a digital computer. The solution agrees with that obtained by the author in an earlier paper [AMR 14(1961), Rev. 125] using a different method.

Reviewer considers the engineering usefulness of the paper to be limited by the restrictive assumptions and by the fact that results are not presented explicitly. L. Mordfin, USA

5899. Venkatraman, B., and Patel, S. A., Creep analysis of annular plates, AFOSR 518 (Polyt. Inst. Brooklyn, Dept. Aerospace Engng. Appl. Mech., PIBAL Rep. 588), 26 pp. + figs., Mar. 1961.

5900. Namestnikov, V. S., Direct and reversed torsion with the condition of creep (in Russian), *Z. Prikl. Mekh. Tekh. Fiz.* 1, 121–122, May/June 1960.

Author has carried out what appear to be careful creep-tension tests on duralumin tubes (15.5 mm o.d., 14 mm i.d., 100 mm long). Tests at 150°C and seven levels of torque show that the application of torque in one direction leads to consistently greater shear strain than is produced by torque in the other direction. Paper concludes with a few comments which contrast the present effect with the well-known Bauschinger effect.

I. Finnie, USA

5901. Dellos, K. P., An improved method for taking into consideration loss due to shrinkage and creep in concrete (in Russian), *Transp. Str-vo* no. 4, 39–42, 1959; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14491.

A formula which had been adopted for estimating loss of stresses is criticized and a method is proposed based on the findings of E. E. Gibshman (Designing of steel structures in combination with ferro-concrete girders). M. A. Zadoyan

Courtesy Referativnyi Zhurnal, USSR

5902. Postnikov, V. S., The linkage of internal friction with the creep of metals at high temperature (in Russian), *Izv. Vyssh. Uchebn. Zavedenii. Fizika* no. 6, 137–144, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14654.

The initial premise is the assumption to the effect that at high temperatures the dissipation of energy depends on the migration of vacancies in the field of stresses produced by the load. All the discussion was centered on the application of the method of torsional vibrations of small amplitude for wire samples which had been subjected to a certain amount of preliminary deformation. The results of the investigations are considered with reference to Al and alloys Al-Mg, Fe-Ni, nichrome "elzhiloy," nimonic 80. It appears from the formula obtained by the author that internal friction can be looked upon as consisting of: (1) the friction of a well-annealed sample when tensioning forces are absent, (2) the supplementary friction when a tensioning force is present, (3) the friction dependent on preliminary deformation with its maximum at a certain temperature T. With increase in the extent of deformation at high temperature creep, T moves towards the side of lower temperatures. Increase in the energy of activation of creep causes increase in T; a similar influence on the location of T at its maximum is shown by the velocity of heating of the sample under test. A deduction is reached, on the basis of the established connection between the magnitude of the friction and the velocity of the creep, to the effect that the more heat-resistant the alloy the lower should be the

value of friction. The paper concludes with an observation on the appreciable influence exercised by the weight of the torsion apparatus on the extent of friction. L. K. Gordienko

Courtesy Referativnyi Zburnal, USSR

5903. Finnie, I., The influence of elevated temperature on the strength of expanded tube joints, *ASME Trans.* **83** D (*J. Basic Engng.*), 2, 315–316 (Tech. Briefs), June 1961.

5904. Shesterikov, S. A., Analysis of disks undergoing relaxation (in Russian), *Z. Prikl. Mekh. Tekh. Fiz.* **1**, 117–120, May/June 1960.

Author uses variational method given in his previous publication [*Akad. Nauk SSSR Otd. Tekh. Nauk* no. 2, 122–123, 1957] to study relaxation of thermal stress in a disk with central hole. All stresses are assumed to relax at the same rate. Creep behavior is presented by $\dot{p} = A\sigma^n p^{-\alpha}$ where $\dot{p}$, σ, p are plastic strain rate, stress and plastic strain invariants. Paper concludes with an application of the solution to a specific case.

I. Finnie, USA

5905. Prager, W., An elementary discussion of definitions of stress rate, *Quart. Appl. Math.* **18**, 4, 403–407 (Notes), Jan. 1961.

Author discusses the well-known concepts of stress rate previously given by Jaumman, Cotter and Rivlin, Oldroyd, and Truesdell. It has been shown that for use in the constitutive equations of plasticity, Jaumman's definition of the stress rate is more preferable. M. M. Stanisic, USA

5906. Gutkin, A. M., Flow of a viscoplastic medium between rotating disks, *Soviet Phys.-Doklady* **5**, 5, 1105–1107, Mar./Apr. 1961. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **134**, 5, 1048–1050, Oct. 1960 by Amer. Inst. Phys., Inc., New York, N.Y.)

5907. Astrakhan, I. M., Solution of the problem of the longitudinal motion of a cylinder in viscoplastic fluids (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 144–145, Jan./Feb. 1961.

5908. Coleman, B. D., and Noll, W., Normal stresses in second order viscoelasticity, AFOSR TN 60–1461 (Mellon Inst., Chem. Div.), 10 pp., Dec. 1960.

5909. Coleman, B. D., and Noll, W., On the foundation of linear viscoelasticity, AFOSR TN 60–1367 (Mellon Inst., Chem. Div.), 42 pp., Nov. 1960.

Plasticity

(See also Revs. 5884, 5896, 5905, 5955, 5956, 5968, 5969, 5974, 5976, 6024, 6043, 6045, 6443)

5910. Lin, T. H., On the associated flow rule of plasticity based on crystal slips, *J. Franklin Inst.* **270**, 4, 291–300, Oct. 1960.

One associated flow rule which has commonly been assumed is that the yield surface and the potential function are identical. It has been shown that this rule applies to polycrystals with infinite elastic modulus. This paper demonstrates analytically that this flow rule is also valid for polycrystals of finite isotropic elastic modulus. For crystals of anisotropic elasticity, the stresses vary from point to point in the aggregate and the plastic strain increment is not strictly normal to the yield surface. For this condition the plastic potential, therefore, deviates from the yield surface and the flow rule does not strictly apply.

M. J. Manjoine, USA

5911. Il'iushin, A. A., Problems of the general theory of plasticity, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **24**, 3, 587–601, 1960. (Pergamon Press, 122 E. 55th St., New York 22, N.Y.)

Completely mathematical general discussion of theory of plasticity is based on five-dimensional stress and strain vectors and their trajectories. Author develops theorems based on the postulation of isotropy and considers behavior in combined tension/torsion tests of thin-walled tubes. Effect of anisotropy developed during plastic deformation in making elastic component of total strain unknown linear function of the stress is considered.

J. M. Alexander, England

5912. Shesterikov, S. A., On the construction of a theory for an ideally plastic body, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **24**, 3, 604–608, 1960. (Pergamon Press, 122 E. 55th St., New York 22, N.Y.)

Author disagrees with a conclusion of Ivlev [AMR **14**(1961), Rev. 663] that only the Tresca yield criterion has any physical significance and proves, using similar extremum principles, that Mises is more realistic. J. M. Alexander, England

5913. Ivlev, D. D., On a class of solutions of general equations of the theory of ideal plasticity (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 11, 107–110, 1958.

Author investigates a class of solutions of Mises' general equations of ideal plasticity. Developed analytical solutions relate to the plastic flow of an ideally plastic material in a beam of rectangular section compressed by rigid plates.

By expressing tangential stress components and displacements as linear functions of coordinates, and by substituting in the Mises' conditions, author develops a system of two partial differential equations. Two classes of solutions are obtained: the first corresponding to the axially symmetrical problem analyzed by Hill and the second includes as a particular case Prandtl's solution for plane deformation of the plastic mass under compression.

M. S. Troitsky, Canada

5914. Dobrokhotov, V. P., Determination of pressure forces with a consideration of the speed of deformation (in Russian), *Vestnik Mash.* **40**, 8, 45–49, Aug. 1960.

Problem of needed pressure force in drawing process through tapered dies for mild steel is discussed. Logarithmic relationship between yield point and speed of the octahedral shearing stress is developed using already existing test data, disregarding work-hardening. Assumption was made that the variation of yield point with the speed of force field is the same as of ultimate strength. Then author uses this established relation to find principal radial stress due to the deformation process. Assumptions are: radial stress is in same direction as radial flow, process is frictionless, surface of equal speed vectors is spherical, no normal stresses acting on free surface at the end of die, material is isotropic, temperature is without change during the drawing process. Final expression for pressure stress and force in material at the intersection of the transverse plane with the die surface (beyond the range of deformation once the drawing process is established) is found and then, to compensate some of assumptions made, 3 corrective coefficients are introduced. One of them is elaborated by author. Measurements on laboratory scale proved the validity of established formula.

Reviewer believes that the final formula is useful but the results of laboratory tests should be published also.

B. O. Kuzmanovic, Sudan

5915. Olszak, W., On an elastic-plastic problem of the eccentric circular cylinder: Part 1, Basic assumptions. Method of elas-

tic and plastic solutions. Elastic problem; Part 2, Plastic and elastic-plastic problems (in English), *Bull. Acad. Polonaise Sci., Ser. Sci. Tech.* **7,** 11, 617–639, 1959.

Author states that while, for general types of material, nonhomogeneity in the boundary-value problem for the elastic-plastic eccentric ring, only numerical integration is possible for certain types of nonhomogeneity, one being that in the paper, analytical integration is possible. In the paper the inversion transformation is applied to the problems of the elastic-plastic and plastic cylinder of eccentric annular cross section and a certain type of nonhomogeneity, together with the related semi-infinite plate with a circular hole.

Paper is in three parts of which only the first two have been published; these are mainly mathematical in content and apparently full discussion of implications is to be given in final part. Reviewer misses a table of notation in a paper of this type and notes that access to many of the apparently untranslated reference are necessary for a full grasp of the papers. Paper will be of most interest to those theoretical stress analysts working to develop elastic-plastic theory. A. F. W. Langford, Australia

5916. Kurdin, N. S., Lower bounds of kinematically admissible limiting loads (in Russian), *Inzbener. Sbornik Akad. Nauk SSSR* **27,** 200–202, 1960.

From the equation for limit analysis [Prager-Hodge, "Theory of perfectly plastic solids"] is derived an equation for lower bound. Numerical calculation is described for a shell revolution with sinusoidal radius under uniform internal pressure. By that method difficulties of integration are avoided.

H. Mussmann, Germany

5917. Bykovtsev, G. I., and Ivlev, D. D., Determination of limiting loads on a body, pressed in the plastic media (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 173–174, Jan./Feb. 1961.

5918. Stepanskii, L. G., and Unksov, E. P., Approximate solutions of certain plane deformation and axisymmetric plasticity problems (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 170–173, Jan./Feb. 1961.

Book—5919. Strel'bitskaya, A. I., Investigation of the strength of thin-walled beams beyond the limit of elasticity (in Russian), Kiev, Akad. Nauk USSR, 1958, 295 pp. + illus. 11 r 90 k; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14194.

The book consists, among other subjects, of an investigation of the elasto-plastic and limiting state of thin-walled beams during torsion, deflection and the joint action of deflection and torsion. An account is given of the present-day position of the theoretical and experimental investigation of thin-walled beams in an elastic state and in the state beyond the limit of elasticity. Basic information is furnished regarding the elasticity calculations and the calculation for the limiting state. A further account is given of the free torsion of a thin-walled beam of open profile in an elasto-plastic state. An examination is carried out of cases of unbounded yield, of linear and stepped hardening. The limiting state is investigated of a thin-walled open profile during the joint action of tension and torsion for a section of arbitrary form. The position of the center of deflection in the limiting stage of a thin-walled profile with one axis of symmetry is examined. A detailed investigation of a girder is made and it is demonstrated that when it is working beyond the limit of elasticity with arbitrary linear hardening the center of deflection migrates more closely to the contour by comparison with its location in the elastic state; it is also demonstrated that a change in the modulus of hardening causes very little alteration in the center of deflection. A study is made of the confined torsion of thin-walled beams of open profile, the finite relation is found between the bimoment, the Saint-Venant torsional moment, and the deflection-torsional moment in the limiting state. Some cases are examined of single-span beams with different forms of stiffening and different torsional loading (concentrated and distributed moments along the length of the beam). It was established that the influence of the deflection-torsion moment on the magnitude of the limiting load is very small and that the limiting load in a number of cases can be determined by consideration of the bimoment only. Details are given of the experimental investigations on the confined torsion of double I beams beyond the limit of the elasticity, which on basic points confirm the theoretical calculations. A study is made of the carrying capacity of thin-walled profiles when subjected to transverse deflection.

The oblique deflection of steel girders beyond the limit of elasticity is looked into. The relations are given between the deflection moments acting in the principal planes of the sections; simple expressions are furnished for the plastic moments of resistance for I beams and girders. Determinations are made for the limiting load of thin-walled girders under the joint action of deflection and torsion. Calculation formulas are derived for the determination of the limiting load of I and girder beams; a study is carried out to ascertain the influence of the bimoment on the magnitude of the limiting load in relation to the eccentricity of the applied force and the length of the girders. A comparison is given of the results of the calculation with the calculation for the elastic state; also a comparison with the experimental data. Finally an investigation is made of the behavior of thin-walled profiles made of ideally plastic material when subjected to simultaneous deflection and torsion.

A supplement deals with tables for the plastic moments of resistance of I beams and girders; tables for the finite correlations between the force components for an I beam and a girder; formulas for the force factors of an I beam and a girder made of steel without an area of yield, when these are in the limiting state.

N. I. Bezukhov
Courtesy Referativnyi Zhurnal, USSR

5920. Ormerod, A., The plastic bending of beams with redundant constraint: Beams loaded in non-principal planes, *Civ. Engng., Lond.* **56,** 656, 336–337, Mar. 1961.

5921. Hodge, P. G., Jr., The Mises yield condition for rotationally symmetric shells, *Quart. Appl. Math.* **18,** 4, 305–311, Jan. 1961.

Author considers thin rotationally symmetric shells, of perfectly plastic material, symmetrically loaded and undergoing small displacements in a way preserving the validity of the classical Bernoulli assumption, according to which straight lines normal to the median surface of the shell before deformation remain straight and normal to the deformed median surface during deformation. Since these assumptions imply that the effect of transverse shear on the deformation is neglected and that the twisting moments are zero, the state of stress is specified by the two median surface or direct forces and the two bending moments—in the meridian and parallel circle directions. Paper is concerned with materials yielding according to the Mises or octahedral-shear-stress criterion. Apparently guided by the well-known parametric form of the ellipse representing the octahedral criterion in two-dimensional cases, author is able to express the two nondimensional direct stresses and the two nondimensional bending moments in terms of three parameters. This is equivalent to a single relation between the four direct stresses and bending moments. Such relation, although not explicitly given, constitutes the "yield condition" for the shell. The two extension rates and the two curvature rates are taken into consideration in the analysis to in-

sure that the compatibility requirements are satisfied. In the process, parametric equations are also found for the extension rates and the curvature rates, thus establishing a parametric form of the "flow law". After obtaining explicit results for the general case for both uniform and idealized-sandwich shells, author specializes his parametric expressions to circular cylindrical shells, circular shells without end load, circular shells under tension, circular plates under bending and to curved beams or arches. Paper describes only the derivation of the "yield condition" and the "flow law." For applications of the theory, author refers to *J. Franklin Inst.* **269,** 362–374, 1960 and other forthcoming papers.

G. A. Zizicas, USA

5922. Ershov, L. V., Elasto-plastic state near a spherical cavity (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 6, 155–156, Nov./Dec. 1960.

5923. Moskvitin, V. V., Torsion of elastoplastic bars during cyclic loading (in Russian), *Naucbn. Dokladi Vyssh. Shkoly. Fiz.-Mat. Nauk* no. 4, 109–117, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14130.

A determination is carried out of the deformation components of round bars of variable transverse section and of prismatic bars of arbitrary transverse section under repeated and momentary loading. A relation is derived which enables the stresses and transpositions to be represented during momentary loading through the corresponding components at the first loading.

V. S. Gotoshiya

Courtesy Referativnyi Zhurnal, USSR

5924. Pivnev, F. A., A method for determining the deflections in the elastoplastic stage of the work of two-hinged steel arches (in Russian), *Trudi Khar'kovsk. In-ta Inzh. Zh.-d. Transp.* no. 28, 153–172, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14169.

Moore's formula is used for the determination of the deflections of arches working in an elastoplastic phase; in this formula a moment is introduced in place of the actual moment of inertia of the I section which is found from the condition of parity with the curve of the "assigned" moment of inertia $I K_1$ (the method of assigned sections). The influence of the longitudinal force is disregarded. When calculating Moore's integrals the curvolinear graphs of the deflection moments are examined as pieces of parabolas of the second order, which enables the integrals to be brought to simple algebraical expressions, the coefficients of which have been tabulated by the author. Investigations are carried out on the peculiarities of calculations for statically indeterminable systems.

A. A. Pikovskii

Courtesy Referativnyi Zhurnal, USSR

5925. Shubin, V. P., Elasto-plastic local deformations and their connection with the coefficient of restitution during impact (in Russian), *Sb. Naucbn. Trudi Tomskii Elektromekbn. In-ta Inzb. Zb.-D. Transp.* **25,** 29–52, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14223.

An experimental theoretical investigation was carried out of the elastoplastic compression and joint impact of elastoplastic bodies. The investigation of the relation between the force driving the small ball into the plate was made on a Jagarin press. The following relation was checked experimentally:

$$\delta = \left(\frac{1}{\alpha_1} P\right)^{2/3} + \left(\frac{1}{S} P\right)^{1/n}$$

Where P is the force driving in the small ball, δ is the magnitude of the local crumpling, α_1, S, n are constants. Strictly speaking the experiments established the magnitude n, without explaining the suitability of the given relation between δ and P. The accuracy of the measurements attainable in the Jagarin press is relatively low, while the author's explanation regarding the adequate precision of the data obtained is debatable. The "instantaneous" taking down of two readings by two laboratory workers (p. 36) is not clear. The coefficient of restitution is determined on the basis of concepts. This part of the paper is issued with numerous misprints (see formula (22), alphabetical symbols on p. 45). The concepts leading up to theoretical determination of the coefficient of restitution are not sufficiently convincing.

N. A. Kil'chevskii

Courtesy Referativnyi Zhurnal, USSR

5926. Pogodin-Alekseev, G. I., and Vasil'eva, A. G., A method for determining localized and even plasticity during tension (in Russian), *Zavod. Lab.* **24,** 11, 1394–1395, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14583.

The method for determining the distribution of plastic deformation, proposed in a previous paper [*Zavod. Lab.* **22,** 8, 979–981, 1956] is compared with the method previously adopted. A good convergence of the curves for the distribution of the deformations was obtained when using both methods.

V. S. Namestnikov

Courtesy Referativnyi Zhurnal, USSR

5927. Olszak, W., and Urbanowski, W., Some fundamental problems in connection with the theory of elastoplastic nonhomogeneous anisotropic media (in French), *Bull. Centre d'Etudes, Rech. d'Essais Scient. Genie Civ. Liege* **10,** 293–310, 1959.

After writing down some general equations, authors state that the equation stating that the sum of the distortional energy and the energy of volumetric change equals the total energy is unique only for "all bodies crystallizing in the regular system, and, in particular, isotropic bodies". For other types of anisotropy, there are two alternate equations, one relating energies of "the first kind" and the other energies of "the second kind." The entire argument is obscure to reviewer, but it seems to be based on earlier papers of the same authors.

A. D. Topping, USA

5928. Olszak, W., Some engineering applications relative to the theory of the plasticity of nonhomogeneous media (in French), *Bull. du Centre d'Etudes, Rech. d'Essais Scient. Genie Civ. Liege* **10,** 311–334, 1959.

Paper is a bibliographical review, primarily of author's own work. Problems discussed are: concentrated load at the boundary of an infinite half-plane; wedge loaded at its apex; cylinder with an eccentric hole; rotating disk; thick-walled cylinder; thick-walled sphere; torsion of a circular bar; pulverulent media; and application of theory of nonhomogeneous media to problems of homogeneous plasticity.

A. D. Topping, USA

5929. Ivlev, D. D., On the theory of ideally plastic anisotropy, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **23,** 6, 1582–1592, 1959. (Pergamon Press, 122 E. 55th St., New York 22, N.Y.)

Paper considers behavior of rigid perfectly plastic material with anisotropic Tresca yield criterion.

Assuming that the whole body is in a plastic state corresponding to one edge of the Tresca prism viz, $\sigma_1 = \sigma_3 = \sigma_1 - R(\theta)$, where $R(\theta)$ is the anisotropic yield limit in the direction of the third principal stress, the author obtains, on substituting in the equations of equilibrium, a hyperbolic system of partial differential equations in the unknowns, the direction of the third principal stress and the mean stress. The Von Mises stress-strain relationship corresponding to the given yield criterion then gives another system of equations. The only conclusion, which in the reviewer's opinion is inadequately proven, is that the characteristics of the two partial systems coincide. The author next rederives, more

rigorously, the above result for the torsional, plane strain and plane stress problems.

No discussion of the significance of the results is given. The paper is fraught with numerous algebraic errors.

W. M. Gray, Canada

5930. Geogdzhaev, V. O., Some questions in the theory of elasto-plastic deformation of anisotropic materials (in Russian), *Trudi Mosk. Fiz.-Tekhn. In-ta* no. 1, 69–96, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14110.

The author, rejecting the hypothesis employed by Mises regarding the incompressibility of the material, builds up a general theory for the elastoplastic deformation of an anisotropic body based on three hypotheses analogous to those found for an isotropic body. The correlations between the deformations and stresses, which were obtained on the basis of the hypotheses put forward, pass over in the isotropic case to known correlations which, when the stresses and deformations are small, result in the correlations for the theory of elasticity of an anisotropic body. When building up the hypotheses the requirement was met that the specific work of deformation of the body shall be fully differential. Directions are given on how to determine the essential constants which enter into the basic system of equations for the elastoplastic deformation of an anisotropic body. The principle is explained in the differentiation of the limits of flow during the tension and the compression of a body.

A. S. Kosmodamianskii

Courtesy Referativnyi Zhurnal, USSR

5931. Gurtin, M. E., Extension of Nadai's Sand Hill analogy to multiply connected cross sections, *ASME Trans.* **83** E (*J. Appl. Mech.*), 2, 301–302 (Brief Notes), June 1961.

Rods, Beams and Strings

(See also Revs. 5898, 5919, 5920, 5921, 5928, 5968, 5969, 5971, 5980, 5985, 5989, 6022, 6088, 6090, 6105)

5932. Teodorescu, P. P., Some considerations in the analysis of straight beams (in Russian), *Rev. Mècan. Appl.* **5**, 1, 127–144, 1960.

Applying methods of the theory of elasticity, author investigates beams of rectangular cross section, the ratio of length to height of which does not exceed 2. In some cases of special load distribution (such as concentrated, triangularly distributed, etc.) for the solution of which Fourier series were used in the past, author uses successfully and with a good approximation the method of biharmonic polynomes. It is also shown that the general case of loading, the deformation of the beam, can be calculated by the methods of strength of material when shear is taken into consideration. A difference less than 5% is obtained when compared with the results obtained when computed by the methods of theory of elasticity. Finally it is shown that the abovementioned beams can be successfully analyzed by the methods of strength of materials both for stresses and deflections.

From author's summary by M. Maletz, USA

5933. Tarasenko, I. I., Calculations for the deflection of a straight cylindrical beam (in Russian), Sb. Nauchn. Trudi Leningrad Inzh.-Stroit. In-ta no. 29, 227–237, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14178.

The moment M_T is determined for the deflection of a cylindrical beam of round section on the assumption that the limit of yield σ_s and the limit of proportionality σ_p are different. An investigation is also carried out of the deflection of a beam made of a material with unidentical values for σ_s and σ_p during tension and compression. In this case it is assumed that the moduli of elasticity too will differ to the same extent.

N. M. Sapozhkov

Courtesy Referativnyi Zhurnal, USSR

5934. Ostromentskii, Yu. Ts., Calculations for nonplane beam and frame systems made up from twin-walled component parts (in Russian), *Trudi Mosk. In-ta Inzh. Gor. Str.-va* no. 8, 64–93, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14315.

A method is proposed for the calculation of the systems given in the title. The beams show eccentricity at the joints or at the supporting fastening. Systems of this type have been designated as "non-plane" by the author. The presence of eccentricities alter the work of construction because it results in the appearance of auxiliary force factors, which are non-existent in a system having ideal joints and supports. Formulas are given for the calculation of single-bay continuous girders and of Γ-shaped frames. In the investigation of the support (joint) n of a continuous beam five equations are derived for the continuity of the deformation, where account is taken of two angles of turning, of deplanation and of two linear displacements of the ends of beams with a span of n and a span of $n + 1$, produced by the force factors M_x, M_y, B, N. In the investigation of the equilibrium of the joint of a Γ-shaped frame seven equations are derived for the possible displacements (three angles of turning, three linear transpositions and deplanation) produced by the seven force components M_x, M_y, M_z, N, Q_y, Q_x, B. Examples of calculations for the Γ-shaped frame, carried out by the methods of forces and by the method of deformation are compared with examples of calculations for an analogous frame with no eccentricities, worked out by D. V. Bychkov ["Calculations for beam and frame systems made up from thin-walled elements," Stroiizdat, 1948]. The difference in the magnitudes of the moments and the bi-moments varied from 6.5–12%. It should be noted that figure 14, borrowed from D. V. Bychkov, should be shown in the form of a plane frame. The author expresses the view that the magnitude of the stresses due to eccentricities in the joints may reach 30% in comparison with the stresses in the same system with no eccentricities operating.

A. I. Strel'bitskaya

Courtesy Referativnyi Zhurnal, USSR

5935. Bychkov, D. V., Calculations for thin-walled beams of single-jointed closed profile (in Russian), *Trudi Moskva In-ta Inzh. Gor. Str-va* no. 8, 5–42, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14352.

A thin-walled beam with a closed rectangular section is investigated when it is subjected to torsion. General equations were obtained by the use of the method of initial parameters for six basic factors, of which three were kinematic and three static. The equations were used for the case when the rigidity of the individual plates of the contour during shear was equal to infinity, and for the case where the beam is so reinforced by means of rigid diaphragms that its transverse section contour does not deform. The paper continued with an investigation of separate reactions on the beam: the presence of a longitudinal force in one of the nodal points of the contour, the application of an external longitudinal bimoment to the end of the beam, the presence of a transverse force at the center of the span in the plane of one of the vertical faces of the section, the application midway along the span of a concentrated torsional moment and bimoment, and also the presence of evenly distributed torsion moments along the length of the beam. In addition, examinations were made of open twin-walled beams with an unbraced grid and with a triangular grid under the action of a longitudinal bimoment on the end of the beam and the action of a torsion moment at the center of the

beam. In all the cases of torsion the investigation either included consideration for deformation due to shear and deformation of the section's contour or without consideration for these deformations. Among a number of cases determinations were made of the numerical magnitudes of normal stresses in the nodal points of a section of a beam with $l = 600$ cm. On the strength of the results obtained and their comparison the author puts forward a series of recommendations in regard to design.

A. I. Strel'bitskaya
Courtesy Referativnyi Zhurnal, USSR

5936. Mishchenko, P. D., Calculations for thin-walled beams of open profile when taking into account shear in the middle surface (in Russian), *Trudi Novocherk. Politekhn. In-ta* 42/56, 54-84, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14353.

Author investigates the influence of shear in the middle surface on the deformation and stresses in a beam. The load and method of fastening the beam are arbitrary. Local stresses at the ends of the beam are not taken into account. The transverse section of the beam is assumed to be invariable in its plane. The problem is solved by the method of successive approximations. In the first approximation the assumption is made that the shear in the middle surface is equal to zero. A result is obtained which agrees with V. Z. Vlasov's result ["Thin-walled elastic beams," Gosstroiizdat, 1940]. In the second approximation, as the initial step, stresses due to shear obtained in the first approximation from the conditions of equilibrium are adopted. Subsequent approximations are obtained analogously. In the case of a load expressed by an algebraical polynominal it is possible to obtain an accurate solution, taking the assumptions made into consideration. The solution proposed is a generalization to include a solution for a thin-walled beam of the solution obtained by L. N. Vorb'ev for a band [*Dokladi Akad. Nauk SSSR* no. 5, 1954]. As the results show, when obtained for tubular and U profiles consideration of the deformation due to shear of the middle surface enables considerable corrections to be made in the determination of the torsional angles and of the tangential stresses in constricted torsion. In the calculations of statically undeterminable short beams for flexure, consideration for shear of the middle surface gives appreciable improvement in the determinations of the deflection moments and transverse forces.

V. A. Mar'in
Courtesy Referativnyi Zhurnal, USSR

5937. Manyu, V., Torsion of shafts with multiple radial grooves or splines (in Russian), *Rev. Mécan. Appl.* **4**, 3, 529-539, 1959.

Author investigates the problem of torsion of solid and hollow circular shafts having single or multiple radial grooves or splines. The developed solutions are based on the application of Dirichlet's problem. The cross sections of the shafts are considered as regions having irregular boundaries. These regions are divided into simply connected subregions bounded by common boundaries, for which the solutions of Dirichlet's problem are well known. It is considered that along the boundaries of each subregion, the boundary conditions are single-valued and equal.

For hollow shafts with single radial groove and single radial spline, twisted by couples applied at the ends of the shafts, the general expressions for tangential stresses and torsional rigidities are evaluated.

The numerical solutions are found in particular cases for the shafts having symmetrically distributed multiple radial grooves and splines of equal size. M. S. Troitsky, Canada

5938. Truesdell, C., Exact theory of self-expanding piston rings (in English), *Ing.-Arch.* **30**, 2, 77-87, Feb. 1961.

Piston ring is regarded as plane elastic curve with axis of symmetry passing through gap. Bending moment is taken proportional to change of curvature, the factor of proportionality EJ being constant. Large-deflection theory is used. Analysis determines initial form of ring so that constant normal pressure applied by cylinder wall causes perfect closure within a cylinder of given noncircular cross section. Special formulas are developed for elliptic cylinders and for nearly circular cylinders with single planes of symmetry. Method of perturbation about exact solution for circular cylinder is developed for nearly circular cylinders. Estimates of accuracy and comparisons of several approximate theories are given. H. L. Langhaar, India

5939. Shimada, H., Influence of the thickness of reinforcements, *Tech. Rep. Tohoku Univ. Japan* **25**, 2, 239-248, 1961.

This paper describes the influence of the thickness of reinforcements in epoxy resin bars with reinforced semicircular notches on one side under bending and with reinforced semicircular notches on both sides under bending or tension. The notches were reinforced by bonding duralumin parts to the bars inside the notches, and duralumin parts have several sorts of thickness. The stress distributions were determined photoelastically. The relation between the maximum shear stress and the thickness of reinforcement for the width of the bar and the reinforcement was determined. From author's summary

5940. Axelrad, D. R., Torsional stiffness of non-circular shafts, *Engineer, Lond.* **211**, 5483, 281-284, Feb. 1961.

Torsional stiffness of shaft whose cross section is composed of three lobes, formed by circle arcs, is derived mathematically using conformal mapping. Shafts of this type may be used instead of splines or feather keys with reduced stress concentration, larger cross-sectional area and moments of inertia. Test results show good agreement when lobes have rounded edges but poor agreement for lobes with sharp corners.

A. H. Church, USA

Plates, Shells and Membranes

(See also Revs. 5874, 5899, 5916, 5921, 5978, 5979, 5980, 5981, 5983, 5985, 6003, 6052, 6081, 6082, 6090, 6098, 6099, 6102)

5941. Conway, H. D., On some systems of equations encountered in thin plate and elasticity theory, *ASME Trans.* **83** E (*J. Appl. Mech.*), 1, 143-144 (Brief Notes), Mar. 1961.

This article presents a method for treating the doubly infinite system of simultaneous equations encountered in the small-deflection bending of clamped plates, rectangular plates in a state of plane-stress, and certain other problems in elasticity. This method consists essentially of satisfying the boundary conditions at discrete points rather than continuously along the boundaries. A numerical example for the clamped plate problem indicates that the method may give faster convergence than the usual method of treating the equations, in some cases.

From author's summary

5942. Samul', V. I., On the application of operational computation for the evaluation of thin plates made of an elastic-ductile material (in Russian), Sb. Nauchn. Trudi Leningrad Inzh.-Stroit. In-ta no. 29, 189-201, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14238.

Author examines the problem of the bending of thin elasto-ductile plates when taking into account the age of the material, making the theory of creep his starting point [see A. R. Rzhanitsyn, "Some questions on the mechanics of systems, deforming with time," Moscow-Leningrad, Gostekhteorizdat, 1949; also in Investigations in constructional mechanics, Moscow, Gos.izd-vo

lit.po stru-vu i arkhitekt., 1954]. The author obtained an equation, analogous to the Sofi Germain equation by adoption of the one-sided Laplace-Carson conversion and of the usual assumptions for elastic plates. The deflection is investigated of a freely supported rectangular elasto-ductile plate for two particular cases, loading with a constant load and with a load varying with time in accordance with the power law.

M. A. Zadoyan
Courtesy Referativnyi Zhurnal, USSR

5943. Bassali, W. A., and Hanna, N. O. M., Bending of curvilinear and polygonal plates symmetrically loaded over a concentric circle, *Proc. Camb. Phil. Soc. (Math. and Phys. Sci.)* **57,** 166–179, Jan. 1961.

Problem of finding stresses and reflections is treated by the complex potential method. The boundaries of thin isotropic slabs consist of regular curvilinear polygons with n sides. Boundary conditions are either clamped or simply supported. The loading is symmetrically distributed over a concentric circle. Plate on z-plane is mapped on the unit circle in the ζ-plane by the mapping function

$$z = c\,\zeta \sum_{\nu=0}^{m} \lambda_\nu \zeta^{\nu n} \qquad (c > 0,\ \lambda_0 = 1)$$

Numerical results found for rectilinear polygonal plates by the present method agree with the ones given by Timoshenko. The discrepancies are due to the small number of terms taken from the polynomial form of the transformation function.

O. Gurel, USA

5944. Ilie, V., On the calculation of oblique plane plates (in Roumanian), *Cluj, Inst. Politehn. Lucrări Stiintifice,* 141–156, 1960.

Author discusses the problem of oblique plane plates built-in on two opposite edges and arbitrarily supported on the remaining two edges; the cases in which these latter edges are built-in, are simply supported or are free, the plate being subjected to a uniformly distributed load, are particularly examined. A variational method of calculation is used in the form given by L. V. Kantorovitch and V. I. Krylov ["Priblijennîe metodî vîssego analiza (Approximation methods of advanced analysis)," Moscow, Gostehizdat, 1950; AMR 5(1952), Rev. 970].

Interesting numerical examples showing the usefulness of the calculation method are given for 45° rhombic plates.

P. P. Teodorescu, Roumania

5945. Levina, Z. M., and Reshetov, D. N., Calculations for and the experimental investigation of the bending of round complex plates with radial and annular ribs (in Russian), *Vestnik Masb.* no. 2, 8–11, 1959; *Ref. Zb. Mekb.* 11, 1959, Rev. 13985.

An approximate calculation is furnished for a system consisting of two thin walls and of radial and annular ribs with the aid of the beginning of possible displacements while taking account of shear in the ribs. The basic criterion of the feasibility of working in such a system appears to be rigidity. The authors continue by extending the results obtained, on the basis of an experimental re-check, to more complex cases of loading; this was accomplished by determining the relative influence of the ribs when the plate supported on the edge is loaded by a central force with the simplest principle of change in the deflections operating.

E. D. Klockhkov
Courtesy Referativnyi Zhurnal, USSR

5946. Zak, L. V., Bending of rectangular plates of variable thickness (in Russian), *Trudî Omskogo S.-kb. In-ta* **26,** 199–208, 1958; *Ref. Zb. Mekb.* no. 11, 1959, Rev. 14004.

A rectangular plate, hinge-supported on opposite sides is the subject of investigation. The rigidity changes linearly in a direction parallel to the supported sides, the load is hydrostatic. The solution is recorded in the form of series and for recalculation 2–3 terms are retained. It is assumed that the solution obtained is also suitable for plates with a linearly variable thickness. For the plates in question curves are furnished for the deflections and the deflection moments based on two numerical values for the geometrical magnitudes and comparisons are made with plates of constant thickness.

P. M. Varvak
Courtesy Referativnyi Zhurnal, USSR

5947. Leites, S. D., The cylindrical bending of steel plates with reinforced edges (in Russian), Materialyi po Stal'm. Konstraktsiyam, **3,** Moskva, 1958, 112–146; *Ref. Zb. Mekb.* no. 11, 1959, Rev. 14166.

Author studies the carrying capacity of plates with clamped or stiffened long sides to avoid transpositions, when under the action of a uniformly distributed transverse load q. It is assumed that the material conforms with Prandtl's diagram. An investigation is made of a very long plate, the deflections of which are considered to be small by comparison with its thickness b, which enables this problem to be merged with the problems of investigating the cylindrical bending of a plate in a linear setting. In the general case the differential equation for equilibrium is recorded as

$$y'' = a\left\{b \pm \left[\frac{q}{2N} \times (l - x) - \frac{M_0}{N} - y\right]\right\}^n \qquad [*]$$

Here $y(x)$ is the deflection, l the span, M_0 and N the absolute magnitude of the supporting moment and the axial force per unit of width of the plate, a, b parameters. The exponent n has the value of 1, -2, $-\frac{1}{2}$ respectively for the elastic state, in cases of one-sided and two-sided flow. It is indicated that the integral for the equation [*] in all cases is expressed through elementary functions or elliptical integrals. Six stages of loading are investigated differing from each other by the number of intervals on whose borders the values of n, a and b change. The solution merges with the fulfillment of the conditions at the end of the intervals and the parity $\frac{1}{2}\int_0^l y''^3 dx + \frac{Nl}{bE}$. The limiting load varies in relation to the adoption of this or that criterion for the limiting state (the formation of a plastic hinge on the support, the attainment of fibrous flow in the span, and so forth). Results are given of the computations of one particular case and also a curve showing the relation of the limiting load to the magnitude l/b for three different criteria for the limiting state.

B. M. Broude
Courtesy Referativnyi Zhurnal, USSR

5948. Ambartsumyan, S. A., Bending of nonlinear elastic three-layered plates (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekb. Nauk, Mekb. i Masb.* no. 6, 86–90, Nov./Dec. 1960.

5949. Kloppel, K., and Schardt, R., Systematic derivation of the differential equations for plane bearing structures (in German), *Stahlbau* **29,** 2, 33–43, Feb. 1960.

Paper deals with homogeneous plates loaded in their plane and laterally to it, and also structures represented by such plates called nets and grids, respectively, built up from two or more series of parallel struts or girders with a small, constant spacing.

Consider a unit stress or strain state (e.g. unit moment or curvature respectively.) The yield relation between these states is represented by reciprocal square matrices; elements of matrices are designated strain or stress figures respectively. If plane

bearing structure is symmetrical to a middle plane, matrices only have 3 lines. If loads act in middle plane, a compatibility condition yields the differential equation of the stress function. In general this is true for an anisotropic plate or a net consisting of dense parallel cables. In the case of lateral loading, equilibrium condition leads to the differential equation of lateral deflection of the plate or grid.

If construction is not symmetrical about the middle plane, 6×6 matrices are needed for relating the stresses in the plane and the moments on the one hand and strains and curvatures on the other. Two simultaneous differential equations are obtained for stress function and deflection.

Results are given in a very instructive table showing the different reciprocities and analogies. The great advantage of determining matrix elements considering unity deformations i.e. stress factors always is clear.

Finally authors expose inaccuracies in using approximate differential equation of M. T. Huber for eccentrically stiffened orthotropic plate. W. Mudrak, Austria

5950. Pister, K. S., and Williams, M. L., Bending of plates on a viscoelastic foundation, *Proc. Amer. Soc. Civ. Engrs.* **86,** EM 5 (*J. Engng. Mech. Div.*), 31–44, Oct. 1960.

An analysis is given of the problem of a thin elastic plate resting on a foundation displaying, in addition to the normal (Winkler) stiffness, a differential shear (E. Reissner) stiffness. Reissner's work is modified, however, to obtain continuity of displacement at the plate-foundation interface.

An illustrative example treats the case of a concentrated line load on a plate resting on a viscoelastic (Voigt) foundation. Graphical results are given for the viscoelastic deflection and bending movement corresponding to the case of an infinitely deep foundation. H. Deresiewicz, USA

5951. Bechert, H., Rectangular clamped plate on elastic beams, subject to uniform load (in German), *Beton u. Stahlbeton.* **56,** 1, 14–20, Jan. 1961.

Rectangular panels of continuous plates with intermediate beams subjected to uniform load are usually considered as plates clamped along all edges and calculated by means of tables given in engineering handbooks. Applying Homberg's theory of gridworks [H. Homberg: "Gridworks" (in German), Forschungshefte aus dem Gebiete des Stahlbaues; Springer, 1951] author corrects these data, taking into account the elasticity of supporting beams and maintaining the zero slopes along the edges.

Numerical examples show that assuming elastic beams as rigid leads to conservative values of bending moments and to a completely different distribution of internal forces and moments A. Kornecki, Israel

5952. Raetz, R. V., Analysis of stresses at junctures of axisymmetric shells with flexible insert rings of linearly varying thickness, David W. Taylor Mod. Basin Rep. 1444, 39 pp., Jan. 1961.

Approximate analysis is presented of short, tapered, conical shell subjected to uniform pressure and axisymmetrical edge loads. In earlier report [AMR **13**(1960), Rev. 3329], bending analysis of cone of constant thickness was based on Geckeler approximation. Present report extends that work by basing bending analysis on equilibrium equation for cylindrical shell of linearly varying thickness. Edge force and moment equations are derived for some typical shell junctures which utilize tapered insert rings. A numerical example is given in which maximum discontinuity stresses in typical cone-cylinder juncture containing flexible, tapered, insert ring are 33% lower than those at juncture containing rigid insert ring. D. O. Brush, USA

5953. Ross, C., The simplified design of concrete hyperbolic paraboloid roofs, *Civ. Engng., Lond.* **56,** 654, 65–66, Jan. 1961.

Paper serves to call attention to increasing need for reliable methods of stress analysis of shell-type saddle-shaped reinforced-concrete roofs. Analysis based on momentless theory and geometric approximations for small rise is remarkably simple, but perhaps too rough for wide use.

H. L. Langhaar, India

5954. Cicala, P., On the elastic theory of the thin cylindrical shell (in Italian), *G. Gen. Civ.* **98,** 12, 937–945, Dec. 1960.

An eighth-order differential equation is deduced for the cylindrical shell, which differs somewhat from the corresponding equations of Donnell, Flugge, Girkmann, etc.

G. W. Housner, USA

5955. Sankaranarayanan, R., Plastic interaction curves for circular cylindrical shells under combined lateral and axial pressures, *J. Franklin Inst.* **270,** 5, 359–366, Nov. 1960.

Interaction curves of external pressure and axial compressive force are derived for plastic collapse of a Tresca rigid-plastic thin cylindrical shell according to now well-known concepts of limit analysis. Problem falls into two regimes, depending on ratio of axial force to material yield stress. Certain simplifying features of this problem enable statically admissible solutions to be found, which are also kinematically admissible.

Results are given for cylinders with one clamped end and one free end for values of governing parameter $c = 1$ and 3, where $c^3 = L^3/ab$ (L = length, a = radius, $2b$ = wall thickness).

No experimental results are included and possibility of failure by buckling, particularly for larger values of c, is not discussed. C. E. Turner, England

5956. Freudenthal, A. M., and Bieniek, M. P., Test of cylindrical shells in the plastic range, *Inter. J. Mech. Sci.* **2,** 1/2, 128–130, Oct. 1960.

Experiments determining the plastic deformation undergone by cylindrical shells having one end fixed and the other free, when subject to internal pressure, are reported and show that certain theoretical analyses lead to erroneous conclusions.

From authors' summary

5957. Nigul, U., Linear, free of hypotheses, equations of motion of elastic circular cylindrical shell (in Russian), Trudy Tallinskogo Politekhnicheskogo Instituta (A), Tallinn, no. 176, 68 pp., 1960.

Linear equations for shells are derived by a method similar to the V. Z. Vlasov theory of "initial functions." The method makes it possible in principle to express all wanted values in the form of Taylor series. It can be used for any type of shell, the only restriction being the convergence of the series, which is formulated mathematically.

For the solution of dynamic problems, exact characteristic equations of a hyperbolic type are derived and the asymptotic error is determined. The characteristic equations are obtained from the basic equations of motion, derived by two different methods.

Simplifying assumptions of the existing approximate theories are discussed. The results of the solution differ widely from those of Yu Yi-Yuan [*J. Aero/Space Sci.*, Nov. 1958].

From author's summary by V. Petrovsky, Czechoslovakia

5958. Pirogov, I. M., State of stress in cylindrical shells with reinforced openings (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 6, 166–168, Nov./Dec. 1960.

5959. Mushtari, Kh. M., Bibliography of nonlinear theory of shells (in Russian), *Izv. Kazansk. Fil. Akad. Nauk SSSR. Ser. Fiz.-Matem. i Tekhn. Nauk* no. 12, 5-15, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13903.

5960. de Leiris, H., and Barthelemy, J., Experimental study of thin or thick-wall pipes constrained in a plane (in French), Bull. Assn. Tech. Marit. Aero. no. 59, 317-345, 1959.

Bulletin no. 867, presented in 1947 to l'Association Technique Maritime et Aéronautique, proposed a theory for analyzing a pipe constrained in a plane and subject to external load and internal pressure. So far, experimental verifiçations have been limited to pipes with $m = e/r$ in the order of 0.1, where e is the wall thickness, r the mean radius of the pipe. In the present paper, authors extend the experimental results to cover cases with $m = 0.025$ and $m = 0.2$ approximately. Both resistance gages and pneumatic extensometers were used. It was found that when m is small, the theory is conservative; when m equals 0.2, for small value of r/R, the theory gives excellent results (R being the radius of the pipe bend). The theory will be on unsafe side if r/R approaches 0.1. The bibliography given contains only papers in French and those published by the same association.

D. H. Cheng, USA

5961. Gorcey, R., Filament-wound pressure vessels, *Mach. Design* **33,** 13, 178, 180, 183, 184, June 1961.

5962. Korbukova, L. D., Bending of an elliptic anisotropic plate clamped along the edges (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 12, 78-84, Dec. 1958.

Author investigates the bending of an elliptical anisotropic plate clamped along the edges and subjected to a concentrated vertical load in the center.

The region of the plate is used as the plane of complex variable. The expression of deflection of the plate is evaluated after a transformation of the general differential equation of the bending of the elliptical anisotropic plate, subjected to uniform loading, as given by Lechnitski ["Anisotropic plates," 1947, Moscow]. The solution of the problem is evaluated as a summary of the particular and general integrals of this transformed equation. By applying the conformal mapping method by means of two analytical functions of a complex variable, the area of the plate is transformed into two complex planes of two auxiliary subplanes. By means of this transformation, the particular solution expressing the deflection of the plate is obtained. However, in the neighborhood of the point of application of concentrated load itself, the particular solution is found separately by application of Cauchy-type integral formula.

The general solution of the homogeneous differential equation is obtained by introduction of certain auxiliary functions, which satisfy the boundary conditions. After certain transformations, these functions are expressed by a system of two integrodifferential equations, which are consequently reduced to the solution of the standard Fredholm integral equation.

The evaluated solution for an anisotropic plate has been applied in a particular case to find the solution of an elliptical isotropic plate, having the same boundary and loading conditions as the anisotropic plate.

M. S. Troitsky, Canada

5963. Hayashi, T., Some plane stress problems of orthotropic material, *Bull. JSME* **4,** 13, 11-16, Feb. 1961.

Author extends work on orthotropic plates to problems with boundaries asymmetric relative to principal crystal axes. Expressions for stresses in terms of harmonic functions of two variables are transformed by conformal transformations appropriate to problem examined. Examples considered are semi-infinite plate with point force on boundary, infinite plate containing elliptic hole, asymmetrically placed relative to elastic axes, under uniform stress and elliptic plate under equal opposing forces at ends of axis. As may be expected, results for asymmetric problems differ qualitatively from those for corresponding isotropic case.

J. E. Adkins, England

5964. Ambartsumian, S. A., On the theory of bending of anisotropic plates and shallow shells, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **24,** 2, 500-514, 1960. (Pergamon Press, 122 E. 55th St., New York 22, N.Y.)

A thin orthotropic shell is considered such that at each point there are three planes of elastic symmetry whose principal directions coincide with the directions of the coordinate lines, α, β, γ. The middle surface is taken as a coordinate surface, in curvilinear orthogonal coordinates α, β coinciding with its lines of principal curvature. γ represents distance along the normal. The basic assumptions are at any point (α, β, γ), $e_\gamma = 0$ and $\zeta_{\alpha\gamma}$ and $\zeta_{\beta\gamma}$ vary according to a specified law depending upon α, β and γ. The case of a plate is then considered and five differential equations with five unknown functions are obtained.

For a thin shell further assumptions are that (1) the internal geometry of the middle surface of the shell of non-vanishing Gaussian curvature does not differ from the Euclidian geometry on the plane, and (2) the principal curvatures of the middle surface are constants. Also in this case five differential equations with five unknown functions are obtained. The problem of a very shallow shell in the form of the mixed method has been reduced to four differential equations with four unknown functions.

As illustrations, two examples of transversely isotropic plate and shell are considered. For a simply supported rectangular plate the results tally nicely with previous results obtained by Vlasov, Mushtari and the author. It has been noted that correction to classical theory due to the effect of transverse shear is more significant than that due to the effect of normal stress σ_γ. In the case of shell the correction is smaller if the influence of flexural phenomena is smaller.

S. C. Das, India

5965. Lekhnitskii, S. G., On the theory of anisotropic thick plates (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 2, 142-145, 1959.

Elastic properties of material considered are described by 5 independent constants, i.e. it is isotropic (E,ν) in each plane layer (x,y) parallel to middle plane, but anisotropic *w.r.* to the z-direction (G_1, ν_1, ν_2).

For this special kind of anisotropy the author generalizes the classical theory of thick plates. He recalls the appropriate stress-strain relationships and, for the two cases of plane stress and bending, he indicates the expressions for displacements and stress components with the help of the Airy stress function, and that of a displacement w_0, respectively.

In the plane stress case displacement and stress components are written as sum of a "mean-value-over-thickness" term and a term involving a factor $(h^2/12 - z^2)$.

In the bending case couples are given by formulas made similar to those of classical thin-plate theory through the use of the quantity $w_1 = w_0 + \lambda\nabla^2 w_0$. If a normal load q acts at $z = -h/2$, extra terms (given in paper) must be added to those due to w_0.

As an application the circular plate under q, with simple support, is examined. Expressions for w and for stress components are stated. The main factor characterizing the postulated anisotropy is the ratio E/G_1. Center deflection f and σ_{max} are computed for $G_1 = 0.1E$, and $0.01E$, respectively. Results show that thin plate theory (f_0, σ_0) underestimates these quantities: $f = 1.17f_0$, and $2.79f_0$, resp.; $\sigma_{max} = 1.021\sigma_0$, and $1.237\sigma_0$, resp.

Paper does not show any derivation of stated expressions.

G. H. Beguin, Switzerland

5966. Hayashi, T., On the plane stress problem in a ring of orthotropic material, *Bull. JSME* **4,** 13, 6–11, Feb. 1961.

Author considers orthotropic plate bounded by concentric circles with general stress distributions on boundaries. Stresses are expressed in terms of harmonic functions of two complex variables and power series expansions assumed for these functions. Boundary conditions are employed to derive relations between the coefficients in these series and these are used to obtain power series expansions for these coefficients. Numerical solutions for an oak plate are found to be similar to those for an isotropic body; results for plywood are different in character.

J. E. Adkins, England

5967. Kosmodamianskii, A. S., State of stress in anisotropic plates with two different holes (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 175–177, Jan./Feb. 1961.

Buckling

5968. Zubchaninov, V. G., Stability of bars as structural elements, acting beyond the elastic limit (in Russian), *Inzbener. Sbornik Akad. Nauk SSSR* **27,** 101–113, 1960.

Author compares the stability of the bars in the elasto-plastic range acting as separate single elements and as integral parts of the whole structure. This analysis is based on the application of the new general theory of the elasto-plastic stability of bars, as recently proposed by Il'yushin [*Inzbener. Sbornik Akad. Nauk SSSR* **27,** 87–91, 1960; see AMR this issue. Rev. 5974]. Existing theories of plastic stability of bars, plates and shells generally analyze such elements as acting separately from the adjacent parts of the whole structure. However, by this approach, the proper behavior of the above elements cannot be properly evaluated during stability loss.

Author compares the stability of hinged bars of rectangular section assuming that the bar is axially compressed at an intensity greater than the modulus of elasticity of the material. He shows that the critical load depends on the character of the bar participation in the whole structure and loading conditions. The intensity of thus evaluated critical loading could vary in the range between the Engesser tangential modulus to the Euler load, but excluding the Euler value itself.

M. S. Troitsky, Canada

5969. Zubchaninov, V. G., Stability of bars beyond the elastic limit in certain structures (in Russian), *Inzbener. Sbornik Akad. Nauk SSSR* **28,** 204-211, 1960.

This article presents further development and application of the theory of elasto-plastic stability of frameworks, originally proposed by Il'yushin [*Inzbener Sbornik Akad. Nauk SSSR* **27,** 87–91, 1960; see AMR this issue Rev. 5974].

Author analyzes the stability conditions of frameworks of different shapes subjected to systems of concentrated loads at the joints. The following cases were considered:

-Hinged bars forming two sides of a triangle.
-Simple beam, propped in the middle by a hinged vertical bar.
-Cantilevered beam, propped at the outside end by hinged bar.
-Bars forming the framework of certain testing machinery.

Author proved that the critical load in certain bars of the given framework systems depends on the intensity and character of application of the external loading and could be greater or smaller than Karman's loading.

Therefore, for structural analysis of the stability of the members in certain frameworks in the plastic range, it is necessary to consider the type of framework as well as the conditions of load application.

M. S. Troitsky, Canada

5970. Aadnoen, L., On the behaviour of compression chords for through-bridges, *Quart. J. Mech. Appl. Math.* **14,** 1, 85–100, Feb. 1961.

A general method is presented for the solution of the differential equations for the stability of a deflected and rotated bar subjected to variable axial loading and constrained elastically along its length against deflection and rotation.

The method is used for the study of the stability of compression chords for through bridges.

From author's summary by A. J. Bignoli, Argentina

5971. Barta, J., Bounds for the buckling load of a thin column clamped at one end and having varying cross sections (in German), *Acta Techn. Acad. Sci. Hungaricae, Budapest* **32,** 3/4, 321–323, 1961.

Author derives a rather interesting result by investigating the differential equation and boundary conditions of a cantilever column undergoing small deflections and having a variable stiffness.

It is shown that bounds for the critical load P_{cr} of a cantilever column of length L are: $1/\phi \leqslant P_{cr} \leqslant L/F$. ϕ and F are the slope and deflection of the free end of the cantilever when used as a beam and loaded with a unit lateral load at the free end. For a cantilever of uniform stiffness EI, reviewer notes that the bounds for $P_{cr}L^2/EI$ are 3 and 2 where the true value is $\pi^2/4$. Suitable variations of this theorem may be applied also to other problems such as a simply supported nonprismatic column symmetrical about the midspan.

R. E. Fulton, USA

5972. Cherry, S., The stability of beams with buckled compression flanges, *Struct. Engr.* **38,** 9, 277–285, Sept. 1960.

Paper represents a study of behavior of thin-walled beams subjected to loads in the range between the load first producing local elastic buckling of the compression flange and the critical lateral buckling load. Only beams with vertical axis of symmetry are considered; the web is assumed to be stiff in relation with the flange. The work consists of two parts: Part I, which is a theoretical study of the critical buckling load from the interaction of local and lateral stability; Part II is a report of an experimental work and a study of relationship between the calculated and measured values of critical moments.

In Part I the derivation of an expression for the critical moment of a section for a beam with locally buckled flange is presented. The method is based upon using an equivalent width for the locally buckled flange—the value of this equivalent width being determined empirically from the tests reported in Part II.

Part II shows an experimental study of beams failing in combination of local buckling and lateral buckling modes. In all, six series of tests are reported, one of which is on T-sections. All specimens were tested under the condition of pure end couples. The critical moments were obtained in each case and a record was made of the onset of local buckling. To create local buckling of flange the thickness of various aluminum extrustion I or T-Sections was reduced by a milling machine.

The agreement between the computed and measured moment appears to be good. The tests show that the strength of beams beyond the occurrence of the first local instability may be appreciable; it depends upon the span length and the material of the section. When local buckling and yielding take place simultaneously the collapse may be sudden.

The work is an interesting study of a difficult and important problem.

N. Khachaturian, USA

5973. Pirvulescu, N. S., Stability formulas for heavy rods (in French), *Rev. Mech. Appl.* **5,** 2, 267–281, 1960.

Critical length of compression b is given by author's formula $b = c^{i,j}_{i,j} f'(A)^{1/2}$. For different cases two empirical formulas are proposed that give the values of coefficient $c^{i,j}_{i,j}$.

A. J. Bignoli, Argentina

5974. Il'yushin, A. A., Elasto-plastic stability of structures composed of bars (in Russian), *Inzbener. Sbornik Akad. Nauk SSSR* **27**, 87–91, 1960.

Author analyzes the buckling strength in the elasto-plastic range of a bar forming an integral part of a structure. The loading transferred onto such an element when stability loss occurs generally will differ when the member is an integral part of the structure and when it is considered as a separate element. The critical buckling force depends on the interaction between the considered element and the whole structure. A hinged bar as part of the structure is analyzed and the influence of the structure is expressed by the stiffness parameter K. At stability loss, when $K > 0$, loading on the bar diminishes and the structure is called underloaded, and when $K < 0$, the structure is overloaded. With this assumption it is proven that at stability loss in the elastic range, the bar is subjected to the Euler loading and should be considered as a separate element irrespective of the interaction between the bar and structure. However, the behavior of the bar differs in the plastic range.

At stiffness parameter $K < 0$, and at stability loss, the load is greater than the critical and approaches Karman's value. With a very stiff structure and overload condition, the critical force is smaller than Karman's value and at underloaded structure, the critical force is greater than Karman's value.

This analysis indicates that for practical stability testing in the plastic range, the relationship between the rigidity of the test machinery and of the member should be considered.

M. S. Troitsky, Canada

5975. Tsatskis, V. I., The stability of an n-stepped beam on elastic supports (in Russian), *Izv. Uchebn. Zavedenii. Str-vo i Arkhitekt.* no. 5, 22–27, 1958; *Ref. Zh. Mekh.* no. 10, 1959, Rev. 12413.

An equation is given for the critical state of a stepped rectilinear compressed beam, with walls which were not thin and on elastic supports, which covers all possible special cases (including the presence of hinged insets). The action of the elastic supports placed at alternating points of sections of the beam is represented by forces and moments correspondingly proportional to the deflections and the angles of inclination of the tangentials to the bent axis of the beam at the points where the elastic supports were disposed.

N. K. Snitko

Courtesy Referativnyi Zhurnal, USSR

5976. Tarasenko, I. I., Calculations for a rigid bar made of a plastic material capable of deformation, subjected to eccentric compression and eccentric tension (in Russian), *Izv. Vyssb. Uchebn. Zavedenii. Str-vo i Arkhitekt.* no. 3, 46–65, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14175.

A method is demonstrated for the calculations of the strength of a bar eccentrically compressed (tensioned) in the plane of symmetry. The material of which the bar is made may possess different degrees of resistance to compression and tension. The hypothesis of plane sections is adopted. In the interval between the limit of proportionality and the limit of yield the relation between the stress σ and the deformation ε is expressed by the equation

$$\sigma = \sigma_{\rho\tau} + (\sigma_T - \sigma_{\rho\tau}) \left(\frac{\varepsilon - \varepsilon_{\rho\tau}}{\varepsilon_T - \varepsilon_{\rho\tau}} \right)$$

Here the indices $\rho\tau$ and T refer respectively to the limit of proportionality and the limit of yield. For brittle materials σ_T represents the limit of strength. It is admitted that the curves $\sigma(\varepsilon)$ are similar in both compression and tension. The limiting state is presumed to be the attainment of the limit yield by the most stressed fiber. It is granted that the axis of the bar is deflected by the half-wave of a sinusoid; investigations are made of the axial force and moment of a section at the middle of the span. A relation is introduced $\kappa_T = P_T/P_0$, where P_T is the limiting magnitude of the axial force with an assigned eccentricity, P_0 represents the same when the Hooke principle holds good up to the limit of yield. Formulas are furnished which enable κ_T to be found for several forms of transverse section. It should be noted that in the case of bars with small flexibility made of material with a clearly expressed area yield the proposed method gives appreciably lower values for the limiting load.

B. M. Broude

Courtesy Referativnyi Zhurnal, USSR

5977. Shevlyakov, Yu. A., and Manevich, I. L., Some cases of stability of a plane form of bending (in Russian), *Dop. Akad. Nauk URSR* no. 6, 627–631, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14346.

The problem is examined regarding the stability of a plane form of flexure of a centilever, slightly distorted beam of rectangular sections for two ways of loading: a concentrated force on the free end and an evenly distributed load acting in the radial direction, and applied to two axis of the beam. By disregarding the square of the small central angle the authors, in the first case, bring the problem into Bessel's equation; in the second case they use the method of Bubnov-Galerkin to obtain the critical load. It was shown that the critical forces calculated with consideration for the inappreciable curvature of the girder exceed the Euler loading for a straight beam if the load is directed to the center of the curvature and decrease when the force is directed on the opposite bearing. I. Ya. Shtaerman [*Sb. Naucbn. Issled. Rabot. Kievsk. Industr. In-ta*, no. 31, 1936] obtained critical forces for the same beams with the load directed vertically.

A. Z. Zarif'yan

Courtesy Referativnyi Zhurnal, USSR

5978. Peterson, J. P., and Whitley, R. O., Local buckling of longitudinally stiffened curved plates, NASA TN D-750, 20 pp., Apr. 1961.

Method is presented for estimating compressive buckling strength of longitudinally-stiffened curved plates. To accomplish this, moment distribution methods were used to extend flat plate design charts to include plate and Z-stiffener proportions representative of curved panels employed in aircraft. Semi-empirical procedure is proposed for estimating increase in stiffness due to curvature, which is less than theoretical increase by amount which depends on radius-thickness ratio, and also on parameter determined by test of similar laboratory specimen. Results are in reasonable agreement with available test data.

S. B. Batdorf, USA

5979. Sherbourne, A. N., The behaviour of a clamped circular plate in compression, *Aero. Quart.* **12**, 1, 51–64, Feb. 1961.

Author determines the load-deflection relationship for an elastic circular clamped plate subjected to uniform thrust in the postbuckling range until yielding is impending. The classical von Kármán large deflection equations are combined with a yield criterion at the center of the plate which requires that the combined stress due to moment and thrust shall not exceed the yield stress.

Through a change of variables the differential equations are put in a form such that step-by-step numerical integration can be carried out using the Runge–Kutta process. A solution proceeds by assuming a stress distribution at the center of the plate. These values combined with the boundary conditions and differential equations are sufficient to determine by integration the deforma-

tions of the plate and the boundary loading needed to cause these effects.

Results are given for the stress, deflection and moment versus the load for a mild steel plate with a yield stress of 30,500 psi and Young's modulus of 26,800,000 psi. R. E. Fulton, USA

5980. Levi, R., The various possibilities of upheaval of slabs (in French), *Ann. Inst. Tech. Bât. Trav. Publics* **13**, 154, 1079–1094, Oct. 1960.

Author begins by showing that "a continuous slab of constant thickness, laid without stress on a rectilinear support, then subjected to longitudinal compression, cannot buckle without preliminary deformation." Significance of this escapes reviewer, since problem appears to be equivalent to showing that a perfect column will not buckle until given a slight displacement. Author goes on to consider the effects of elasticity of the foundation, defects of alignment, transverse joints, temperature gradient, and anchored joints. All analysis is two-dimensional, and results apply to rails as well as highway and runway pavements. Author favors continuous rails and slabs, and points out that open joints in practice fill with dirt and so do not provide the intended expansion gap. A. D. Topping, USA

5981. Massonnet, C., Mazy, G., and Tanghe, A., General theory of the buckling of orthotropic, rectangular plates, clamped or freely supported at the edges, provided with stiffeners, parallel to the edges, having considerable flexural and torsional rigidities, Univ. de Liege Publ. no. 71, 223–262, 1960.

The authors, first of all, describe a general theory of buckling of an orthotropic, rectangular plate, which may be provided with horizontal and vertical stiffeners having considerable flexural and torsional rigidities.

The theory is based on the energy criterion and the deformation due to the buckling is represented by a double series whose components are the buckling deformations of a prismatic bar hinged at both ends or fixed at both ends.

In the second part of the paper this theory is applied to the study of isotropic plates without stiffeners, having two parallel edges, or all four edges, fixed and subjected to compression, to combined bending and compression or to shear. A study is then made of plates subjected to pure bending, clamped at the horizontal edges and provided with a horizontal stiffener, having a tubular section, of relative ordinate 1/3, 1/4 or 1/5.

From authors' summary by F. N. Birkett, Scotland

5982. Kornishin, M. A., Bending and stability of slanting cylindrical panels and plates with elastic ribs (in Russian), *Izv. Vyssh. Uchebn. Zavedenii: Aviats. Tekhn.* no. 3, 34–38, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13950.

Author investigates the large deflections in slanting cylindrical panels, rectangular in plane, which are subjected to an even transverse load; the panels are strengthened by elastic ribs, flexible in the tangential plane. Known equations are recorded which contain the deflection function w and the stresses function Φ in the median surface. The method of Bubnov-Galerkin is utilized; the functions w and Φ in the first approximations are presented in the form

$$w = w_1 \cos\frac{\pi x}{2a}\cos\frac{\pi y}{2b}$$

$$\Phi = \Phi_1\left(1+\cos\frac{\pi x}{a}\right)\left(1+\cos\frac{\pi y}{b}\right) + \psi_1(y) + \psi_2(x) + \frac{p_1 y^2}{2} + \frac{p_2 x^2}{2}$$

where $2a$, $2b$ are the sides of the panel, p_1, p_2 are the forces in the median surface, applied to the edges, $\psi_1(y)$, $\psi_2(x)$ are unknown functions determinable from the conditions of the interlinkage of the plate with the ribs. Boundary cases are examined where the edges of the panels deflect freely or remain rectilinear. A boundary case of a plane plate is analyzed.

A. S. Vol'mir
Courtesy Referativnyi Zhurnal, USSR

5983. Gazizov, B. G., The stability of an annular plate (in Russian), *Izv. Kazansk. Fil. Akad. Nauk SSSR, Ser. Fiz.-Mat. i Tekhn.* no. 12, 155–164, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14034.

An investigation is made of the elastic stability of a thin annular plate evenly loaded over the internal contour by tensioning forces acting in the plane of the plate and directed towards the center. The problem is solved by the Bubnov-Galerkin method with the use of isothermal and polar coordinates. Three types of edge fastening are examined: clamped, hinge-supported, the internal edge rigidly clamped with the external edge hinge-supported. In all the cases, with the exception of a very narrow ring, the loss of stability proceeds with the formation of an appreciable quantity of circumferential waves. A. V. Sachenkov
Courtesy Referativnyi Zhurnal, USSR

5984. Houghton, D. S., and Johns, D. J., Linear buckling of an axially reinforced pressurized cylinder, Coll. Aero. Cranfield, Note 110, 12 pp., Oct. 1960.

Using small deflection theory, a general buckling solution is given for a longitudinally stiffened pressurized cylinder under axial compression. Approximations are obtained for panel buckling in a short cylinder and buckling of a long cylinder under axial load both with and without internal pressure. Comparisons are made with other solutions and the effects of internal pressure are discussed. B. G. Johnston, USA

5985. Pshenichnov, G. I., Stability of lattice-type cylindrical shallow shells (in Russian), *Inzbener. Sbornik Akad. Nauk SSSR* **29**, 77–79, 1960.

Author extends a previously presented method of strength calculation [*Inzbener. Sbornik Akad. Nauk SSSR* **26**, 1958; AMR **14**(1961), Rev. 2393] to calculation of buckling of a simply supported shell segment from uniform external pressure. The equations neglect the bending stiffness in the tangent plane and the torsional stiffness of the lattice members and, hence, only yield a finite buckling load because these modes of deformation are ignored. An extension of the author's more general theory [AMR **14**(1961), Rev. 5281] would seem more appropriate since these stiffnesses may well govern buckling of the structure.

R. W. Leonard, USA

5986. Vekua, I. N., On the conditions required to ensure a momentless stressed state for the equilibrium of a bulging shell (in Russian) *Soobshch. Akad. Nauk GruzSSR* **20**, 5, 525–532, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13905.

Examinations are made of buckled shells with a regular median surface bounded by intermittent smooth contours. It is assumed that surface forces are acting on the shell and that both tangential projections of the edge forces on the contour are assigned. The problem set is to find conditions to which the load would have to conform, (surface and edge forces) resulting in a corresponding momentless stressed state. This question is investigated without regard for the nearness of the stressed state obtained by this procedure to the actual stressed state of the shell. It was shown that an essential and sufficient condition for the existence of a momentless stressed state of equilibrium is the requirement that the sum total of the elementary work of the surface and contour forces, applied to the shell on the transpositions, corresponding to an arbitrary infinitely small deflection of the median surface shall be

equal to zero. The load which fulfils the conditions detailed above is called momentless.

The question is investigated of how to modify the assigned load to make it momentless. Two methods for accomplishing this are indicated. One of these consists of the selection of a complementary load, satisfying some condition naturally emanating from the method of solution of the problem (the question of the mechanical existence of that condition is not referred to). A load of this nature the author calls the potential load and demonstrates that, generally speaking, the given load can be made momentless by adding to it a certain potential load. Exceptions might be cases where the shells have no more than one opening. Another method is also indicated which enables a momentless load to be obtained, in particular, by a change in the weight of the unit area of the shell. Factual attainment of this may be achieved, for instance, by means of variation in the thickness. The author gives no indications of how his results can be utilized in the case where the shell is in contact with some other form of construction (say, a support) and where in the corresponding points reactions emerge, hitherto unknown. A. A. Gol'denveizer

Courtesy Referativnyi Zburnal, USSR

5987. McKenzie, K. I., The buckling of a pressurised stiffened cylinder under axial load, Aero. Res. Counc. Lond. Rep. Mem. 3198, 16 pp., 1961.

An analysis is made of the general buckling of a pressurized stiffened cylinder under axial load. Torsional buckling of the complete cylinder, local buckling of the stringers and pure compressive failure of the stringers are also considered, and the design of stiffened pressurized cylinders is discussed, with an example.

From author's summary

5988. Krivosheev, N. I., The stability of a cylindrical shell under the action of shear (in Russian), *Izv. Kazansk. Fil. Akad. Nauk SSSR. Ser. Fiz.-Matem. i Tekhn. Nauk* no. 12, 133–142, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13945.

A determination is effected by the method of small vibrations of the critical stresses of shear when a cylindrical shell of finite length and a cylindrical panel are subjected to shear. The initial differential equations for the distorted surface of the shell are taken as corresponding to the form of the approximate equations in the theory of slanting shells. The use of the approximate equations in the theory of slanting shells for the case of a short cylindrical shell can be justified by the fact that the loss of stability is followed by the formation of a large number of creases and that within the limits of a single crease the given approximate equations hold good. The frequencies of the natural vibrations are determined in the form of series, the coefficients of which contain the parameter τ^*, proportional to the shear stress τ. The condition of equality to zero of the lowest frequency of the natural vibrations determines the critical shear stress. Following a number of complex conversions, relatively simple means are obtained for the numerical determination of the critical shear stresses with any required degree of precision (within the limits, of course, of the precision of the initial equations in the theory of slanting shells). Tables are furnished in which comparisons can be made of the values of parameter τ^*, calculated by the formulas of the author of the article under review and by the formulas of other authors. An analysis is given of the applicability of the approximate solutions. L. I. Balabukh

Courtesy Referativnyi Zburnal, USSR

Vibrations of Solids

(See also Revs. 5884, 5902, 6032, 6234, 6382)

5989. Prasad, C., Transverse vibrations of a deep beam, Proceedings of the Fifth Congress on Theoretical and Applied Mechanics, Univ. of Roorkee, Roorkee, India, Dec. 23–26, 1959; Kharagpur, Indian Soc. of Theor. and Appl. Mech., C. 123–C. 128.

Under plane stress conditions, two-dimensional equations of motion for a deep beam are derived. After neglecting the rotary shear term, an approximate solution for displacement components u and v and stresses σ_x and σ_y is obtained. Higher approximations are made without a clear basis for the choice of the equations nor is it indicated that these approximations necessarily lead to more accurate results. A comparison with Timoshenko beam theory would have been helpful to assess the changes due to plane stress assumptions. G. Sonnemann, USA

5990. Chuvilovskii, V. S., Transverse vibrations of bars and plates subject to surface forces (in Russian), *Inzbener. Sbornik Akad. Nauk SSSR* **25,** 81–91, 1959.

5991. Kolesnikov, K. S., Deflections of beams in the case where their supports are in vibration (in Russian), Raschetyi na Prochnost' v Mash., (MVTU **89**), Moskva 1958, 226–233; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14088.

The paper furnishes a supplement to the Bubnov-Galerkin method for the problem on the forced transverse vibrations of beams of transverse section; it is assumed that the motion is due to the given vibrations of the supports' sections. One example is cited and the approximate solution in this case showed no appreciable difference from the precise solution.

Ya. G. Panovko

Courtesy Referativnyi Zburnal, USSR

5992. Ramachandran, S., Electrical analogy method of determination of torsional vibrations in multicylinder diesel engines, *J. Instn. Engrs., India* **41,** 3 (Part 2), 115–127, Nov. 1960.

Article summarizes the well-known analogy between dynamical systems of mechanical and electrical nature, and points out how this has been applied to problem of torsional vibration of a multicylinder diesel engine. Much of the material is a recapitulation of three articles in *G.M. Engng. J.* (**1,** no. 3, 1953, article by C. G. Goohs; and a series of two articles by A. B. Hamilton in **5,** nos. 2 and 4, 1958). A numerically different (though physically similar) example is given. R. L. Sutherland, USA

5993. Romaniv, O. N., Bending vibrations of shafts with disks of unequal central moments of inertia (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 6, 98–104, Nov./Dec. 1960.

5994. Aronson, A. Ya., Influence of an added mass of water on vibrations of a submerged shaft (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 5, 41–47, 1959.

5995. Skudrzyk, E. J., Kautz, Barbara R., and Greene, D. C., Vibration of, and bending wave propagation in, plates, *J. Acoust. Soc. Amer.* **33,** 1, 36–45, Jan. 1961.

Authors discuss treatment of vibrating systems in terms of the concept of characteristic impedance and illustrate the method by computations of the flexural vibrations of flat plates. The theoretical predictions are compared with experimental results and the treatment is extended to discuss the propagation of bending waves in infinite plates and shells on lines similar to those used for reverberation theory in room acoustics.

H. Kolsky, USA

5996. Zhodzishtii, G. A., The influence of the initial stresses (produced as the result of forging) on the frequency of the free vibrations of circular saws (in Russian), *Izv. Vyssh. Uchebn. Zavedenii: Lesn. Zh.* no. 5, 107–118, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14548.

A study is made of the title subject, a round disk being taken to epresent an instrument used in sawing. The characteristics required for the evaluation of the magnitude of the hammer forging were determined by the Bubnov-Galerkin method with the following assumptions in force: the thin round disk is in a plane axially symmetrical stressed state, the vibrations of points on the disk are perpendicular to its plane, the stresses do not exceed the limits of elasticity, the deformations in the unhammered regions are elastic while in the hammered regions they are plastic and of inappreciable extent, the inner edge of the disk is closed, the outer-free. A typical calculation is furnished of the influence of the stresses due to the initial hammer forging on the frequency of the free vibrations of a circular saw disk.

B. G. Gazizov
Courtesy Referativnyi Zhurnal, USSR

5997. Gavrilov, Yu. V., Determination of frequencies of free vibrations of elastic circular cylindrical shells (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 163–166, Jan./Feb. 1961.

5998. Shyakhtin, A. V., Periodic motion of a piecewise linear system subject to the action of impulses (in Russian), *Trudi Inst. Mashinoved., Akad. Nauk SSSR* **21**, 81/82, 30–45, 1960.

Author considers a mass on a bilinear spring. The mass receives an impulse Q whenever it is at $x = 0$. He finds the periodic motions for several cases: when there is no damping, in the presence of Coulomb friction, and when the mass strikes a barrier having a coefficient of restitution. The stability of the periodic solution is examined by deriving and solving a difference equation for the error propagation, and, more effectively, by a method of contraction mapping involving the phase plane. The analysis is applicable to the motion of a pile driver.

E. E. Zajac, USA

5999. Neuber, H., The dynamics of pneumatic hammers (in German), *ZAMM* **41**, 1/2, 72–86, Jan./Feb. 1961.

Dynamic properties of pneumatic hammers are determined analytically using an idealized dynamic model consisting of four masses: handle, body, piston, chisel. Damping is neglected and a Fourier series is used for the air-pressure-time function.

Exact velocity time functions of the four masses are obtained in an explicit form. It is shown that the introduction of a spring between the body and the handle does not lead necessarily to a reduction of mechanical efficiency of the hammer and the force on the arm holding the hammer may be considerably diminished.

The paper reviewed is the most complete known analytic treatment of this practical problem. W. Fiszdon, Poland

6000. Biderman, V. L., and Bukhin, B. L., Analysis of critical speed of rolling of pneumatic tires (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 52–57, Jan./Feb. 1961.

6001. Kurdyumov, A. A., Vibration of deck coverings with the ship in motion (in Russian), *Trudi Leningrad Korablestroit. In-ta* no. 22, 107–117, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14391.

Paper contains an investigation of the forced vibrations (without resistance) of a rectangular covering made up of transverse bulkheads. The solution of the problem merges with the finding of the forms of the forced vibrations of the transverse joist produced by an evenly distributed harmonic load. At points of intersection of the transverse joists and longitudinal beams rigidity is met with, positive (elastic support) or negative (vibrating concentrated mass) and harmonic disruptions occur. The very same problem is solved for the determination of the resonance amplitudes when there is internal resistance proportional to the first stage of velocity for the deformation but the modulus of elasticity is replaced by the function for the decrement of the damping, which enables not only the form but also the values for the changes of position of points in the covering to be found.

V. K. Zhitomirskii
Courtesy Referativnyi Zhurnal, USSR

6002. Vathitov, M. B., Calculations for the natural form and frequencies of a monolithic wing (in Russian), *Izv. Vyssh. Uchebn. Zavedenii: Aviats. Tekhn.* no. 1, 16–27, 1959; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14379.

An investigation is carried out on a cantilever sagittal plate of variable section. It is assumed that the elastic axis is a straight line right up to its fastening point. The hypothesis is postulated on the invariability of the form of the transverse section of the plate. The problem is solved by the Ritz method; the function for the form of the free vibrations of the plate in the direction of the chord is assigned, while the function for the form in the direction of the span is looked for. This enables electronic machines of intermittent type to be used without any difficulty. The iteration method is utilized for the determination of the function of the form and direction of the span; the equations for the vibrations are presented in matrix form. The method is well-confirmed by the experiments. S. Ya. Makarov
Courtesy Referativnyi Zhurnal, USSR

6003. Dugundji, J., On the calculation of natural modes of free-free structures, *J. Aerospace Sci.* **28**, 2, 164–166 (Readers' Forum), Feb. 1961.

The standard matrix method for calculating the modes and frequencies of unrestrained structures is reviewed and it is clearly demonstrated that the rigid body mode modifying matrix is independent of the particular choice of restraints with respect to which the flexibility matrix is computed and may be applied to any such flexibility matrix to obtain the unrestrained modes and frequencies. F. L. DiMaggio, USA

6004. Pei, M. L., Vibration of shear buildings by flexibility method, *Proc. Amer. Soc. Civ. Engrs.* **87**, EM1 (*J. Engng. Mech. Div.*), 13–21, Feb. 1961.

Using the well-known iterative method for finding the lowest eigenvalue [see, e.g., Karman and Biot, "Mathematical methods in engineering," McGraw-Hill, 1940, pps. 201–202] the frequencies of a shear building are obtained. F. L. DiMaggio, USA

6005. Doribas, A. A., Zhilin, N. V., Krasnikov, N. D., Marchenko, L. L., and Sovast'yanov, N. V., Vibrations of concrete structures on rock foundations subject to the action of blast loads (in Russian), *Zh. Prikl. Mekh. Tekh. Fiz.* **2**, 140–143, 1960.

6006. Cherdantsev, V. V., Calculations for the components of vibromachines viewed as elastic girders (in Russian), Sb. Trudi Vses. Nauk-i In-ta po Mash. dlya Prom-sti Stroit. Materialov **1**, 33–47, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14105.

The problem is investigated on the forced vibrations of a girder where the conditions for the support of the ends alter during the vibration process. For the duration of one period the ends of the girder are alternately in a state of being rigidly hinge-fastened or of being free. Use is made of the well-known linear equation for small transverse plane vibrations of a beam with a constant transverse section, and boundary and initial conditions are formulated which take into consideration the specific peculiarities of the problem. No numerical calculation and analysis of the results is given. The conclusions at the end of the paper have no direct relation to the postulated problem. D. V. Vainberg
Courtesy Referativnyi Zhurnal, USSR

6007. Klein, G. H., New way finds natural frequency of nonlinear vibration isolators, *Prod. Engng.* **32,** 6, 54–55, Feb. 1961.

Author describes and illustrates by numerical example an approximate analytical method for computing the natural frequency of a mass mounted on a vibration isolation support which has a nonlinear load-deflection curve. The solution is applicable when the vibrating system is subjected to a uniform acceleration of any magnitude, including zero. The procedure given is approximate and restricted: approximate because it is a limiting solution for the exact frequency on the assumption that the amplitude of the motion approaches zero; restricted because it is developed on the assumption of a parabolic slope-deflection relationship.

The exponents indicated in Eq. [9] lead to an imaginary result. The exponents should be 1/3 rather than 1/2.

W. J. Moreland, USA

6008. Gurtin, M. E., On the use of clearance in viscous dampers to limit high frequency force transmission, *ASME Trans.* **83** B (*J. Engng. Industry*), 1, 50–52, Feb. 1961.

The forced (sinusoidally excited) oscillations in a system of one degree of freedom are investigated. The system has linear restoring forces kx; the linear damping forces $c\dot{x}$, however, enter into play only after the absolute value of the displacement x exceeds a threshold value a.

The response curve in the vicinity of resonance is similar to that of the linearly damped system without clearance; for high frequencies it resembles that of the undamped system.

K. Klotter, Germany

6009. Sykes, A. O., Isolation of vibration, when machine and foundation are resilient and when wave effects occur in the mount, *Noise Control* **6,** 3, 23–38, May/June 1960.

The *effectiveness*, or *insertion loss*, a measure of the isolation provided by a vibration mount, is defined as E, the ratio of vibratory velocity amplitude of the juncture when a foundation and machine are directly connected to the vibratory velocity (when a mount is used) of either (a) the foundation-mount juncture or (b) the machine-mount juncture, depending upon the direction in which the isolation is desired. Equation is given by which effectiveness may be evaluated for a massless spring-dashpot mount isolating a nonrigid machine from a nonrigid foundation if the mechanical impedances of the machine, mount, and foundation are known. Several sets of curves present the effectiveness values in db for a variety of machine and foundation impedances.

Limitations caused by coupling between mounting points prevent the application of this theory to many-mount systems, except for certain defined conditions. Evaluation of effectiveness for realistic case of mounts constructed of materials which have distributed mass, elasticity, and damping is discussed and covered by formula; resulting wave effects in the mounts under these conditions reduce the effectiveness, in most cases, particularly at standing-wave resonances.

Information is given for estimating the characteristic impedances, frequency constants, and damping factors of simple mounts: natural and neoprene rubber, and helical springs.

R. L. Sutherland, USA

6010. Postnikov, V. S., The damping of vibrations in a cylindrical sample (in Russian), *Fiz. Metallov i Mettallovedenie* **6,** 3, 522-533, 1958; *Ref. Zh. Mekh.* no. 10, 1959, Rev. 12346.

An examination is made of the torsional vibrations of an elastic-viscous cantilever beam with a round transverse section with consideration for the damping. The problem on the free torsion vibrations of the beam in the presence of relaxation and after-effect leads to a differential equation of the third order. The form is found of the elastic line of the beam during torsional vibrations and a determination is made of the logarithmic decrement of the damping. For pure aluminum in shear along the boundaries of the grains the logarithmic decrement increases with increase of temperature up to 285° and then drops sharply to zero at 294°. Similar incongruity with the experimental data can be explained by the fact that the author accepts a value for the internal friction determined by experiment from the logarithmic decrement when a different link is established between these magnitudes than that obtained in the paper under review. The necessity is emphasized to find a theoretical explanation for the sharp increase of internal friction at high temperatures.

O. V. Luzhin

Courtesy Referativnyi Zhurnal, USSR

6011. Yuzefovich, G. I., Dynamic stability of saw disks (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 46–51, Jan./Feb. 1961.

6012. Isaev, V. S., Dependence of predominant frequencies in the spectra of impulsive vibrations on the number of visible periodic impulses (in Russian), *Trudi' Inst. Fiz. Zemli Akad. Nauk SSSR* no. 6 (173), 114–119, 1959.

6013. Savinov, G. V., Parametric self-excitation of auto-vibrations (in Russian), *Nauchn. Dokladi Vyssh. Shkoly. Fiz.-Mat. Nauk* no. 2, 106–109, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13001.

The conditions governing the parametric self-excitation of vibrations in a nonlinear contour, described by the equations given below, are investigated

$$\frac{d}{dt}\left[L(q,\dot{q},t)\dot{q}\right] + R\,\dot{q} + \frac{q}{c} = 0$$

when L is the self-induction, R the resistance, c the capacity, q the condenser's charge. The general conditions for the self-excitation of the vibrations are obtained from the energetic concepts. These conditions are applied to a special case

$$L = L_0\,(1 + m \sin 2\,\omega\, t) \qquad (m < 1)$$

The investigation continues with an examination of autonomous vibration systems with various principles for the reverse link. For instance

$$L = L_0\,(1 \pm m\, q\, \dot{q}), \qquad |m\, q\, \dot{q}| < 1$$

and also for the case where L is only dependent on q or $\dot{q}$. In all three cases the required conditions were found for steady excitation.

A. P. Proskuryakov

Courtesy Referativnyi Zhurnal, USSR

Wave Motion and Impact in Solids

(See also Revs. 5814, 5995, 6221, 6225, 6235, 6416, 6419)

6014. Miles, J. W., Low-frequency motion of bodies in an elastic wave field, *J. Acoust. Soc. Amer.* **32,** 11, 1396–1401, Nov. 1960.

The mean translation and rotation of a body having elastic constants and a density that differ only slightly from those of an otherwise homogeneous medium in which it is imbedded are calculated for an arbitrary incident wave field. The dimensions of the body are small compared with the wavelength. Problem is reduced to the evaluation of two integrals in potential theory and explicit evaluations are given for an ellipsoid. Results are applied to the motion of a sphere and a prolate spheroid under the influence of plane P and S waves.

From author's summary by M. L. Baron, USA

6015. Ang, D. D., Transient motion of a line load on the surface of an elastic half-space, *Quart. Appl. Math.* **18,** 3, 251–256, Oct. 1960.

The problem of the title is one of plane strain, the load moving with a velocity varying as a step function of the time. The transient character of the load gives rise to a "resonance" effect for motion at velocities approaching that of the Rayleigh wave.

H. Deresiewicz, USA

6016. Gusein-Zade, M. I., and Kuzin, P. A., Effect of an impulsive loading on an elastic layer, resting on a liquid elastic half-space (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 64–72, Jan./Feb. 1959.

Authors consider the axially symmetric form of the problem described by the title. Fourier-Bessel and Laplace transforms are applied to space and time variables. By extracting shift operators, a series solution in the transformed domain in terms of a sequence of waves generated by reflections from the boundaries is obtained. The lengthy formulas for the inversion to the space and time domain are numerically calculated on the symmetry axis, and plots of stresses and displacements on this axis are displayed.

E. E. Zajac, USA

6017. Kravtsov, G. S., On the form of hodographs of reflected waves of multi-layer elastic media (in Russian), *Ucb. Zap. Tomskii. In-ta* no. 32, 89–93, 1958; *Ref. Zh. Mekh.* no. 10, 1959, Rev. 12264.

An investigation is made of the peculiarities of spatial hodographs of longitudinal reflected waves for the case of a laminated nonhomogeneous elastic medium with plane-parallel boundaries for the division of the layers and a weak differentiation in velocities (V_k is the velocity of the longitudinal waves in the k layer) and for small two-face angles φ between the diurnal surface and the plane boundary of the first layer; the layers form a "pack," all the layers being parallel to each other in the pack, with a general angle φ. It is claimed that for $\varphi < 15^\circ$ and $C_k = V_1/V_k < 0.3$, with support of simple numerical calculations the spatial hodographs of reflected longitudinal waves practically possess axial symmetry which manifests itself with precision when $\varphi = 0$. A nomogram is drawn for the evaluation of the asymmetry of a spatial hodograph with known geoseismic conditions C_k, φ and b_k (b_k is the thickness of the k layer).

E. I. Shemyakin

Courtesy Referativnyi Zhurnal, USSR

6018. Miles, J. W., Motion of a rigid cylinder due to a plane elastic wave, *J. Acoust. Soc. Amer.* **32,** 12, 1656–1659, Dec. 1960.

Author considers the plane strain problem for a rigid cylinder in an infinite linearly elastic medium. The steady-state motion of the cylinder under the action of both pressure (P) and shear (S) waves with harmonic time histories is obtained under the assumption that the motion of points on the cylinder boundary are identical with those of the medium (no cavitation). A formal solution to the P-wave problem was given originally by Sezawa with no numerical results. Author presents displacement-frequency curves for a medium with a Poisson's ratio of $\nu = 1/4$ for several ratios of the density of the cylinder to the medium. Numerical results for the rotation due to an incident S wave are also given for the case where the densities of the cylinder and the medium are equal.

M. L. Baron, USA

6019. Perzyna, P., Propagation of elastic-plastic waves in a non-homogeneous medium (in English), *Arch. Mech. Stos.* **11,** 5, 595–612, 1959.

Author gives a general discussion of one-dimensional wave equation describing both elastic and plastic regions. Linear stress-strain relations for nonhomogeneous materials in elastic and plastic condition are assumed. Also, linear strain-hardening is assumed. A case for which pressure on the surface increases monotonically from zero is given special consideration along with a particular case of nonhomogeneity. A bibliography of nineteen papers is appended.

W. H. Hoppmann, USA

6020. Tsepelev, N. V., Reflection of elastic waves in a non-homogeneous medium (in Russian), *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 1, 11–17, 1959; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14043.

With the assistance of the beam method for the calculation of the intensity of the wave fronts [see V. M. Babich, *Dokladi Akad. Nauk SSSR* **110,** 3, 355–357, 1956] the problem is investigated on the reflection of waves from the so-called weak boundaries dividing two nonhomogeneous elastic media, on which the elastic characteristics of the medium are continuous while their gradients undergo disruption. The case is examined of the contact of two elastic semi-spaces. A transient wave falls on the boundary, the wave having a disruption of some type on the front. The wave is reflected from the boundary; it has on the front a disruption of unit size of the smallest order (should the falling wave, for instance, possess a shock wave of displacement then the reflected wave will have interrupted displacements, but on the other hand the stresses will possess a shock wave). Formulas are derived for the coefficients of reflection from the boundary of the division, and other formulas which enable the intensity of the wave fronts in cases of reflection of waves from boundaries of this type to be found. It is indicated that this method can also be used to investigate "still weaker" boundaries of divisions, when all the derivatives from the elastic characteristics of the medium down to the k - 1 order are continuous while their $k - e$ derivatives will have a shock wave.

V. M. Babich

Courtesy Referativnyi Zhurnal, USSR

6021. Kats, M. M., Calculations for beams under the action of a momentary impulse (in Russian), *Trudi Omskogo S.-kh. In-ta* **26,** 209–216, 1959; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14084.

Calculations for beams subjected to the action of a momentary impulse, as is customary, are merged with the investigation of the free vibrations of a beam with an assigned curve for the initial velocities and for zero values for the change of position of the beam's axis. The curve for the initial velocities is resolved into a series in accordance with the beam's functions and, consequently, the vibration motion being sought proves to be the sum total of the corresponding monotone vibrations with assigned initial velocities and zero transpositions. The curve of the momentary impulse is considered to be symmetrical relatively to the center of the beam. Cases are investigated of hinge-supported and clamped ends. A collated table is given of the deflections, deflection moments, transverse forces in the case of a single-bay, hinge-supported beam for a number of symmetrical curves of the impulse (square parabola, sinusoid, triangular curve, an evenly distributed curve).

N. I. Bezukhov

Courtesy Referativnyi Zhurnal, USSR

6022. McNiven, H. D., Extensional waves in a semi-infinite elastic rod, *J. Acoust. Soc. Amer.* **33,** 1, 23–27, Jan. 1961.

This paper discusses a mode of symmetrical vibration which can take place at the end of an elastic rod as a result of coupling between pure extensional waves and waves with complex wave numbers which attenuate rapidly in amplitude with distance from the free end of the rod. The author shows that such coupling can result in waves of the type observed experimentally by J. Oliver in his work on wave propagation.

H. Kolsky, USA

6023. Pandratov, S. A., Calculations for the loss of strength in the jibs of excavators and cranes when subjected to loads of short duration (in Russian), *Sb. Trudl Mosk. Inzh. Stroit. In-ta* no. 26, 107–111, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14445.

The case is investigated of the action on a beam of the impulse

$$P(t) = P \text{ with } 0 \leqslant t \leqslant t_1$$

$$P(t) = 0 \text{ with } t > t_1$$

A problem of this type had been set earlier by M. A. Lavrent'ev and A. Yu. Ishlinskii [*Akad. Nauk SSSR (N. S.)* **64**, no. 6, 1942]; use is made of the solution obtained by them for the determination of the dynamic form of loss of stability in dependence on the relation of the acting load to the Euler load. The equation for the motion of the beam with consideration of the nonlinear factors was recorded in the form evolved by V. V. Bolotin [*Akad. Nauk SSSR*, "Transverse vibrations and critical velocities," no. 1, 1951]. After conversion and effecting some simplifications, this equation is changed to a form enabling the solution to be obtained in series

$$q_k = q_k^{\circ} + q_k^1 u + q^2{}_k u^2 + \ldots$$

where u is the small parameter. The next step is the finding of only the first approximation, the determination of conditions in which q_k for a given $t = t_1$ will have a maximum value; an expression for q_k is found for a sufficiently small t_1. In the case where an impulse of short duration and of arbitrary form is acting on the beam it is recommended to replace it by an equivalent rectangular impulse.

G. M. Chuvikin

Courtesy Referativnyi Zhurnal, USSR

6024. Salvadori, M. G., Skalak, R., and Weidlinger, P., Spherical waves in a plastic locking medium, *Proc. Amer. Soc. Civ. Engrs.* **87,** EM 1 (*J. Engng. Mech. Div.*), 1–11, Feb. 1961.

Work is concerned with spherical wave propagation in an infinite plastic locking medium created by time-dependent pressures on the surface of a spherical cavity. Various inputs, such as a constant pressure, a center of dilatation, an adiabatic gas expansion, and an exploding point mass, are considered, and closed form asymptotic solutions, short- and long-time, are derived for these cases.

J. Miklowitz, USA

6025. Perzyna, P., Analysis of propagation of plane elastic-plastic waves in a non-homogeneous medium: Part 1, Finite strains; Part 2, Infinitesimal strains (in English), *Bull. Acad. Polonaise Sci. Ser. Sci. Tech.* **8,** 9, 485–502, 1960.

The problem is incompletely defined by use of the one-dimensional wave equation. The internal resistance coefficient as well as the density is assumed to be a function of space variable x. Author first develops equation of motion for condition of large strain with a general functional relation among stress, strain, and x. He uses method of characteristics to indicate solution. Next he linearizes stress-strain law but still assumes existence of elastic and plastic regions. He shows the interative solution of a Volterra integral equation, giving the displacements. Finally, he discusses unloading process.

In second part author analyzes problem of small strain, studies propagation of front of elastic-plastic wave, and again uses method of characteristics. He solves problem for loading condition by reducing it to two Picard problems. Iteration procedures are again used. It is learned that nonhomogeneity leads to dispersion of waves. Solution of the unloading problem by Kaliski and Osiecki is mentioned. A short incomplete bibliography is appended.

W. H. Hoppmann, USA

6026. Geniev, G. A., Some questions in the dynamics of visco-plastic media (in Russian), Issled. po Vopr. Teorii Plastichnosti i Prochnosti Stroit. Konstruktsii, Moskva, 1958, 123–133; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14215.

An investigation is made of the plane problem concerning the steady flow of a visco-plastic medium. The Saint-Venant conditions for the flow are supplemented by two additions of a term taking into account the forces of viscosity. The components of the stresses' tensor expressed through the mean normal stress ρ and two inclination angles for two areas of maximum shear β have items containing components of the velicity of the particles. The terms containing two components of velocity and mass forces separate out when substitution takes place in two equations for motion. Knowledge of these terms merges the problem with the solution of a system of quasilinear equations of the first order of an hyperbolic type for ρ and β. The following approximate numerical method is proposed for the determination of the terms in question. The system of differential quasilinear equations of the first order of the hyperbolic type for the modulus of the vector of velocity ν and the angle of inclination ∞ of that vector and the equations for the characteristics of this system contains in the coefficients the magnitude β. The uncharacteristic line along which ρ, β, ν and ∞ are assigned is broken up into cuttings along each of which β is presumed to be a constant, with the result that the characteristics in each of the "triangular" regions are rectilinear. A solution is worked out for ν and ∞. This expresses analytically the "free" terms in the equations for σ and β; the next step is the derivation of a solution for this system (more accurately designated as "the system of characteristic equations") by means of the method of finite differences. The method is determined for the "agglomeration" of the refines when solving the first problem.

V. S. Lenskii

Courtesy Referativnyi Zhurnal, USSR

Soil Mechanics: Fundamental

(See also Revs. 5927, 5928, 6024, 6032)

6027. Grubnik, N. A., Investigation of the acoustic properties of underwater soil at high acoustic frequencies, *Soviet Phys.–Acoustics* **6,** 4, 447–454, Apr./June 1961. (Translation of *Akust. Zh., SSSR* **6,** 4, 446–453, Oct./Dec. 1960 by Amer. Inst. Phys., New York, N.Y.)

A procedure is described for measuring the coefficient of reflection of sound from an undersea bottom as a function of frequency and angle of incidence. Data are given on the acoustic properties, obtained by the procedure outlined, of certain bottoms under lake and ocean conditions.

From author's summary

6028. Shankin, P. A., Ice action on concrete lining of slopes (in Russian), *Gidrotekh. Stroit.* **30,** 9, 36–39, Sept. 1960.

6029. Gamainov, A. I., Vertical ice pressure (uplift) due to the change of ice level (in Russian), *Gidrotekh. Stroit.* **30,** 9, 40–42, Sept. 1960.

6030. Sapozhnikov, V. G., and Fisenko, G. L., Calculations for slopes of protruding form (in the order of discussion) (in Russian), Sb. Statei po Vopr. Issled. Gorn. Davleniya i Sdvizheniya Gorn. Porod. (VNIMI no. 32), Leningrad, 1958, 171–188; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14263.

A solution is furnished for the theoretical problem which is based on the investigation of the ultimate stressed state of slopes of bulging form for a homogeneous medium. A simplified method for the calculations of slopes of similar form is described. The authors conclude, as the result of analysis made, that it is wrong to represent slopes of concave form as the only slopes strictly

theoretically justified. It is noted that slopes of convex form may prove to be expedient in determined conditions.

Z. V. Maslova-Pil'gunova

Courtesy Referativnyi Zhurnal, USSR

6031. Golubkov, V. N., and Goncharov, Yu. M., Investigation of the deformation of a pile in the soil under the action of a horizontal load (in Russian), *Izv. Vyssh. Uchebn. Zavedenii: Str.-vo i Arkhitekt.* no. 4, 38-46, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14274.

Results are described of tests carried out on the deformation of metallic tubular piles when subjected to horizontal forces. Two piles were under observation; they were driven into the soil by twisting and were placed together at a distance of 5m between their axes. The diameter of the piles was 1.22m. The piles, each 14 m long, were embedded to a depth of 8m. The horizontal load was applied to the top of the piles and was produced by a hydraulic jack through a brace between the piles. The deformation of the piles was measured by wire deflection meters and the reactive soil pressure by electro-tensometers. The metallic pile flexes like a cantilever beam fastened at some distance from the earth's surface when subjected to the action of a horizontal force. This distance increases with increase of the horizontal force. Consequently the embedded part of the pile does not rotate as a whole round a point but only flexes up to a determined depth; the lower part remains practically immovable. The length of this part depends on the magnitude of the horizontal force being used, on the elastic properties of the piles, the nature of the soil and the correlation between the free and the embedded parts of the piles. An investigation was made of the maximum value of the magnitude of the reactive pressure of the soil at the point where the flexure of the pile began. At earth level the reactive pressure was nearly equal to zero. A comparison of the experimental data with the theoretical calculations for the piles is not given in the paper.

K. E. Egorov

Courtesy Referativnyi Zhurnal, USSR

Soil Mechanics: Applied

(See also Revs. 5950, 6275, 6278)

Book—6032. Lorenz, H., Dynamics of foundations [Grundbau-Dynamik], Berlin, Springer-Verlag, 1960, viii + 308 pp. DM 46.50.

This textbook is a welcome review of present state of knowledge and first of its kind in the field. It is devoted to analysis of soil and soil-supported structures under influence of forced vibrations. After the introduction in first chapter, the second chapter gives an analysis of harmonic vibrations, nonharmonic vibrations, vibrations of elastically supported planar bodies and nondamped and damped vibrations of systems of bodies, as they appear in machine foundation design. Third chapter deals with dynamics of framed structures. It repeats results which were published in book by Hohenemser-Prager, "Dynamik der Stabwerke," Berlin, Springer-Verlag, 1933 and completes it with new results in analysis of forced undamped vibration of beams.

Fourth chapter is devoted to soil dynamics and gives results of long lasting experiments of Hertwig, Lorenz and others, which were begun about 1930 in Berlin in Degebo Society. Starting from analysis of vibrating point on elastic half-space, there is analyzed dynamic investigation of soil properties, further vibratory compaction of soil, and, finally, vibratory driving of piles and sheet piles.

Book gives a very thorough and complete survey of pertinent German, English and Russian literature. The explained theory could be useful for preparing exact solutions of complicated vibration problems, now made possible by use of electronic computers, which were already used on similar problems of earthquake analysis [see AMR **12**(1959), Rev. 796 and AMR **13**(1960), Rev. 4935]. Book requires knowledge of higher mathematics and is therefore directed mainly to advanced designers and research students. The author can be congratulated for systematic and pedagogic treatment of subject, starting from known principles of mechanics and giving all steps of analysis up to the final solution.

Z. J. Bazant, Czechoslovakia

Book—6033. Szechy, K., and Kezdi, A., Dictionary of foundations and soil mechanic constructions [Alagutak, alapozas, foldmuvek, talajmechanika], Budapest, Terra, 1960, 250 pp. 45 Ft.

Book—6034. Antonescu, I. P., edited by, Foundations for hydraulic structures [Lucrari de geotehnica, fundatii si constructii hidrotehnice], Bucuresti, Institutul de Studii si Cercetari Hidrotehnice, 1959, 242 pp. (Paperbound)

6035. Mednikov, I. A., The strength of an asphalt-concrete road surface on a cement-concrete foundation (in Russian), *Trudi Mosk. Avtomob.-dor. In-ta* no. 22, 54-62, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14279.

A method of calculation is described for the stressed state and strength of the asphalt-concrete layer of a road surface which has an underlay of a more rigid type: a cement-concrete foundation. The author adopts the assumption at the start that the concentration of vertical forces due to the rigidity of the underlayer is compensated by the deconcentration of the stresses due to the horizontal forces. Formulas are given for the maximum tension, compression and tangential stresses and also for the deformation due to compression and tension in relation to the coefficient of adhesion of the vehicle wheels with the road, the modulus of deformation and the coefficient of transverse deformation of the asphalt-concrete. At the rated temperature the magnitude of the limiting pressure is calculated for an aperiodic regime for the stressed state in accordance with Moore's theory of strength, and for a periodic regime, in accordance with the theory of maximum normal stresses. The build-up of deformations in the road surfaces is determined by the theory of inheritance, while taking into account the temperature of the asphalt-concrete. In this procedure the deformation of the road surface should not exceed the linear deformation established by experiment as representing the limit. Conditions are given for the experimental determination of the limit for the linear deformation of the asphalt-concrete in conformity with the creep curve, with stresses and temperature constant for the calculation-time interval. Tests are recommended for single-axis compression and for tension of test samples of the road surface representing an elasto-viscous body whose residual deformations are small. An approximate form for the sought function of influence is also submitted; this was arrived at by theoretical approach. The period of time adopted for the calculations is selected on the basis of practical concepts regarding the intensity of work and form of the transport vehicles for different numbers of 24-hour periods according to the season of the year and while taking into account the changes occurring in the relaxation properties of an asphalt-concrete of a given composition. The sequence essential to the carrying out of the calculations to check the strength of the road-covering is furnished.

S. A. Roza

Courtesy Referativnyi Zhurnal, USSR

6036. Green, H., Long-term loading of short-bored piles, *Géotechnique, Lond.* **11**, 1, 47-52, Mar. 1961.

Bored piles 12-in. and 14-in. diam. × 10 ft long were loaded with their design loads 1 year after casting and their settlements were observed over a period of 4 years. Settlement continued throughout the period of the test but the rate of settlement was small after the first 3 months. The settlements at loads in excess of the de-

sign loads were small compared with those of similar piles subjected to short-term tests. From author's summary

6037. Uematu, T., and Nakamura, S., A study of the screw conveyor, *Bull. JSME* **3,** 12, 449–455, Nov. 1960.

Paper treats an unusual problem in soil mechanics, that of transport of sand in an open V-shaped iron trough by a rotating screw. Experiments with medium sand show that:

A. There is an optimum pitch for a given screw diameter

B. The tip clearance should be as small as possible but not less than three times the mean diameter of the transported material.

C. The driving torque for the screw increases sharply when the rate of discharge increases beyond a certain value for a given conveyor.

Author's theoretical analysis is in general agreement with observations.

Reviewer doubts whether angle of shearing resistance of sand used (33.4°) and angle of skin friction of the sand against the screw (32.3°) were obtained under comparable conditions. Generally, skin-friction angles between sand and metal are between 35 and 65% of the corresponding angles of shearing resistance *at the same porosity.* Reviewer regrets that shape of sand used was not accurately described. The torque might be expected to be much higher for materials of low roundness (i.e. angular materials) than for one of high roundness. T. K. Chaplin, England

Processing of Metals and Other Materials

(See also Revs. 5840, 5914, 6011, 6064, 6065)

Book—6038. Campbell, J. S., Principles of manufacturing materials and processes, New York, McGraw-Hill Book Co., Inc., 1961, ix + 674 pp. $9.75.

This text concentrates on basic principles of manufacturing materials and processes and is valuable in a survey course for students; it is designed to educate engineering undergraduates.

Commercial applications of fundamentals learned in chemistry and physics courses are described; the chapters on metallurgy and heat treating are outstanding in this respect. Metal casting is comprehensively and lucidly covered. All unnecessary detail is avoided.

Extensive use has been made of line drawings instead of photographs for many of the illustrations. They offer clarity and are advantageous.

Rolling, forging and other mechanical working processes are brought up to date and succinctly described. The joining and machining chapters provide the student with data on the how and why rather than emphasis on present-day equipment which may soon be obsolete.

Appended to each chapter is an adequate bibliography. The index might have been more detailed.

The book should also be useful to engineers in manufacturing, as a handy reference. H. J. Heine, USA

6039. Hockett, J. E., Calculation of rolling forces using the Orowan theory, *Trans. Amer. Soc. Metals* **52,** 675–697, 1960.

Early theories of rolling are mentioned, and objections to them are presented. Orowan's "exact" theory is described and discussed briefly. Objections to the use of the "exact" theory are stated and the means of overcoming these objections, viz., modifications of the theory and the use of electronic computation, are given.

Results of roll pressure and force calculations for uranium sheet by the modified "exact" theory are reported and compared with measured pressures. An actual rolling problem is given, and the recommendations of consultants are used as a basis for roll pressure calculations.

The Orowan "exact" theory, as modified, combined with accurate compressive true stress-strain data and high-speed computation, is shown to be a valuable means of providing rolling mill designers with accurate information—thereby eliminating much of the guesswork in rolling mill design.

From author's summary by F. C. DeNie, Holland

6040. Green, A. P., Plane strain theories of drawing, Instn. Mech. Engrs., Prepr., 3–16, 1960.

After reviewing some of the existing plane strain theories of drawing, a new approximate method is proposed which includes work hardening, friction and redundant work in the calculation of die pressure and drawing load. Formulas are derived for drawing through a wedge-shaped die by using analytical approximations for the stress-strain curve. The error involved in calculating a mean coefficient of friction from the measurement of forces acting on each half of a wedge-shaped die is also analyzed.

B. W. Shaffer, USA

6041. Westwood, D., and Wallace, J. F., Upper-bound values for the loads on a rigid-plastic body in plane strain, *J. Mech. Engng. Sci.* **2,** 3, 178–187, Sept. 1960.

When the body is under normal pressure and Coulomb friction, the process of tube ironing is considered. It has been shown that the upper-bound values for the loads can be determined by using the polygon of forces. The method is then extended to sheet drawing and extrusion and plane compression.

From authors' summary by S. C. Das, India

6042. Miyagawa, M., A new method of hot deep drawing of sheet metals, *Mem. Fac. Technol. Tokyo Metrop. Univ.* no. 10, 709–718, 1960.

Preliminary tests on aluminum blanks are described showing improvement for one-step draw operation. New method combines preheating of the blank flanges and simultaneous controlled cooling of the wall (or cylindrical part) of the drawn cup. Method aims to achieve optimum relation between hot ductility of heated flange, higher strength of cooled wall, and favorable transient thermal stresses caused by rapid cooling. F. Forscher, USA

6043. Kalpakcioglu, S., On the mechanics of shear spinning, *ASME Trans.* **83** B (*J. Engng. Industry*), 2, 125–130, May 1961.

Shear strain, shear strain rate, specific energy and the tangential force in shear spinning have been formulated for an idealized process. For 1100 aluminum good agreement has been obtained between theory and experiment. F. Forscher, USA

6044. Hahn, R. S., On the analysis of random errors in precision grinding operations, *ASME Trans.* **83** B (*J. Engng. Industry*), 2, 131–141, May 1961.

Statistical methods are applied to internal grinding problem. Effect of input stock variations, forces and grinding elasticity on output errors is studied. W. H. Sparing, USA

6045. Kaczmarek, J., Investigation of progressive loading of a face milling edge when entering the cut, *Arch. Mech. Engng., Polish Acad. Sci.* **8,** 1, 27–60, 1961.

Dr. Kaczmarek, director of the Metal Cutting Institute at Cracow (Poland), deals with a problem which, according to his information, causes 80% of carbide tool failure in face milling operations.

Following the path of Kronenberg and Etin, he concentrates on initial contact and cut entering coefficient. Instead of determining the latter as a quotient of removed section by cut entering time, he proposes to define it as a quotient of main cutting force by entering time. Author starts his geometric and kinetic analysis of cut entering impact with Kronenberg's parallelogram SVUT. He classifies the cut entering types according to location of initial contact and computes cut entering time with provision for set-up rigidity. Entering time and forces are tested with an ingenious set-up using strain gages to measure main and feed cutting forces. Performed experiments covered the influence of machining parameters (approach angle, feed, speed and depth of cut), and cutting edge geometry (radial and axial rakes, lead angle).

Author's experiments showed an extensive variation in edge loading progress in cut entering, as affected by many factors. Impact of cut entering is much better reflected by the new proposed definition of cut entering coefficient than by the old one of Kronenberg. The test results show numerical influences of investigated parameters and stress a lengthening of cut entering time by lack of rigidity. Kronenberg's parallelogram is very descriptive. For practical reasons author advocates VUT cut entering type rather than VST and VFT. He is aware of a need of further investigation, but does not define it in any detail. On the whole the report seems to be a valuable contribution to face milling stress analysis and should be of particular interest to makers of milling machines and cutters.

A. Niedzwiedzki, USA

6046. Selwood, A., and Molgaard, J., Wire brushing of aluminum mechanism of "orange peeling," *Wear* **3,** 5, 394–400, Sept./Oct. 1960.

The brushing of aluminum by rotary nickel silver wire brushes gives surface changes due to low temperature welding, and not surface melting. This is shown by examination of the surface produced at different speeds of brushing, with and without lubrication, and by experimental and theoretical estimation of surface temperature.

From authors' summary

6047. Marcu, V. V., and Freund, P., Corrosion protection by mixed layer of sprayed metal and film-forming products (in French), *Rev. Mécan. Appl.* **5,** 2, 283–293, 1960.

Among other means of corrosion protection are combined layers of sprayed metal covered by paint or varnish. Zinc or aluminum are usually applied. For economy reasons their replacement by steel has been tested. The study reports results obtained in testing samples, covered with a layer of sprayed steel and a supplementary layer of paint, and then corroded by electrochemical means. Although tests give encouraging results, long duration corrosion tests in atmospheric conditions will be more conclusive.

From authors' summary by A. Niedzwiedzki, USA

6048. Kayama, N., and Okita, H., A trial of acoustic measurement on the study of metal flow, Waseda Univ., Castings Res. Lab. Rep. no. 11, 1–11, 1960.

The sources of sound and its relation to flow conditions occurring when molten metal is poured into the mould are investigated experimentally. It may be expected that fitness of pouring conditions could be judged from acoustic measurements, but more experiments seem to be needed.

F. E. Borgnis, Switzerland

Fracture (Including Fatigue)

(See Revs. 5880, 6117)

Experimental Stress Analysis

(See also Revs. 5847, 5881, 5911, 5960)

6049. Margulis, A. I., Stresses in the vicinity of the bottom closure of a cylinder loaded by internal pressure (in Russian), *Vestnik Mash.* **40,** 3, 35–37, Mar. 1960.

The distribution of stress and the maximum stress are determined by frozen stress patterns on models of styrolalkyd. The models have different ratios b/r_m and ρ/b (r_m = average radius, b = wall thickness, ρ = curvature radius) of junction from the cylindrical part to the bottom. The ratio σ_{max}/σ_t (σ_{max} = maximum stress in the junction, σ_t = tangential stress at the inner surface) is represented graphically as function of only one parameter, the dimensionless ratio $\rho b/r_m^2$.

H. Mussmann, Germany

6050. Sevast'yanov, V. Ya., A method for measuring the deformations and thickness of the removed layer of a plane test sample for purposes of calculating the residual stresses (in Russian), *Zavod. Lab.* **25,** 2, 202–203, 1959; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14734.

A method is proposed for the measurement of the deformation of a plane sample and the simultaneous measuring of the thickness of the removed layer. The basis of the method is the means adopted by N. N. Davidenkov for measuring the flexure of a plane sample [*Zh. Tekhn. Fiz.* no. 12, 1939]. A description and a schematic plan of the apparatus used are given for the simultaneous measurement of the deformation and thickness of the removed layer, as well as the procedure adopted for the determination of the thickness of the layer and for the deformation of the sample. Results are given for the measurement of the flexure and thickness of the removed layer of a sample prepared from a steel mark St.20, 20 × 3 × 110 mm, and also a graph showing the distribution of residual stresses over the section of the surface layer. The calculations were made in accordance with N. N. Davidenkov's formulas.

Yu. G. Maksimov

Courtesy Referativnyi Zhurnal, USSR

6051. Bazilevskii, N. G., The use of flexible mirrors for modelling stress functions (in Russian), *Inzhener.-Fiz. Zh.* **1,** 9, 82–93, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14736.

An investigation is made of some of the properties of lines reflected onto a screen from arbitrary curvolinear surfaces (flexible mirrors). Relations are derived for general and particular cases when the mirror surfaces are cylindrical, conical, and so forth. In order to find the stress function the well-known analogy is utilized between the differential equations for the plane problem and the deflection of a plate loaded with force or deformation factors along the contour. For the purpose of modeling the stress functions by means of the method indicated it is essential to have a plate with a mirror-polished surface and appliances for its deflection, and also apparatus for the reception of the picture of reflected lines. As an example an investigation is carried out of a rectangular plate with a round orifice. The plate, 23.7 × 33mm, with a diameter for the orifice of 10.5 mm was made of black celluloid and was subjected to even tension along its short sides. The author states that the results of the experiments were in good agreement with the theoretical data.

P. M. Varcak

Courtesy Referativnyi Zhurnal, USSR

6052. Hardenberg, D. E., Stresses at nozzle connections of pressure vessels, *Experimental Mech.* **1,** 5, 152–158, May 1961.

Author presents data on principal stresses and maximum shear stress in critical regions of branch-type connections to cylindrical

shells loaded by internal pressure. Author reports standard strain gage technique used and computer methods for calculating principal stresses. Localized stress condition is shown graphically for one nozzle design. L. W. Smith, USA

6053. Fessler, H., and Foreman, J. J., Large strains of drum heads studied with silicone rubber models, *J. Mech. Engng. Sci.* **3**, 1, 42–49, Mar. 1961.

A technique for producing accurate models is described. The models were subjected to internal pressure and the displacements of points on the outer surface were measured with a traveling microscope. From these measurements the radii of curvature and the rotation of the elements were determined graphically and the bending moments calculated.

The greatest bending moments were found to be proportional to the percentage increase in head height and almost independent of Poisson's ratio of the material except for the change in flexural rigidity. The effect of large strains on the bending moments in any drum head can therefore be calculated if the relation between increase in head height and pressure has been determined and the bending moments for one pressure are known.

From authors' summary

6054. Heckmann, W. K., Analytical photoelastic determination of maximum root stresses on various shapes of gearwheel tooth (in German), *ZVDI* **103**, 6, 237–240, Feb. 1961.

In the past it was impossible to calculate accurately the peak stresses occurring at the root radius of gearwheels, deriving from the geometrical form. A stress formula was arrived at, based on theoretical considerations, which assumes the tooth to be a special form of fixed-end beam. Consequently, the application of the formula is not restricted to gear teeth. The form factors occurring as parameters in the formula are photoelastically determined. The root stresses established in this manner, in the course of various tests, were compared with photoelastic measurements and running tests. From author's summary

6055. Clyne, G., Fessler, H., and Wilson, R. W., Improvements of photoelastic technique for strain measurement on flat surfaces, *Brit. J. Appl. Phys.* **12**, 1, 8–10, Jan. 1961.

The use of the impact glue, Eastman 910, produced stronger bonds than could be achieved with epoxy resin adhesives. Epoxy resin layers bonded on to flat polished Dural surfaces were torn by fatigue cracks in the metal without extensive bond failure. The bond strength was improved by controlled etching and hot soaking of the Dural surface (as shown by Fessler and Haines in 1958) before bonding.

Impact glue bonds between epoxy resin layers and flat polished alloy steel surfaces withstood static strains of 0.3% (slightly beyond yielding) in pure tension and 1.5% in eccentric tension.

From authors' summary

6056. Konovalov, M. D., Rikhter, V. A., and Tarapin, V. N., A photoelectric device for the measurement of torsion moments (in Russian), *Izmerit. Tekhnika* no. 2, 28–29, 1959; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14743.

A description is given of the construction of a photoelectric device, designed for the measurement of the torsion moment on the shafts of constructional and road-transport machines, which recorded results on a band oscillograph without amplification and without taking any current. The device is designed in two variations: for setting on the shafts which can be taken off the machine and for setting on the shafts which cannot be removed from the machine for its assembly. The devices are supplied with current from accumulators. A plan is furnished of the construction and electrical scheme of the device. The error occurring in measurements in field conditions corresponds to 3–4%, in laboratory conditions this can be reduced to 2%; the device gives good results at temperatures from −20 to +35°. Yu. G. Maksimov

Courtesy Referativnyi Zhurnal, USSR

Material Test Techniques

(See also Revs. 6038, 6067, 6070, 6076, 6441)

Book—6057. McGonnagle, W. J., Nondestructive testing, New York, McGraw-Hill Book Co., 1961, xi + 455 pp. $15.

Book comprises a useful catalog with appropriate discussion of nondestructive test techniques in following areas: visual testing, pressure and leak testing, liquid penetrants, thermal methods, x-ray and gamma radiography, ultrasonics, dynamic testing, magnetic methods, electrical and eddy current methods and thickness measurements. Possibly an occasional reference for those engaged in experimental mechanics. G. Gerard, USA

6058. Davis, C. D., and Hunter, S. C., Assessment of the strain-rate sensitivity of metals by indentation with conical indenters, *J. Mech. Phys. Solids* **8**, 4, 235–254, Nov. 1960.

Paper proposes a testing method for investigating the behavior of metals and alloys subjected to impact stress of a few milliseconds duration. The method uses a conically tipped tungsten carbide indenter mounted on a pendulum block which impacts a plane surface of the specimen. An analysis of impact indentation process for a conical indenter is made, using a quasi-stationary approach which neglects the elastic stress-wave propagation. The analysis gives the maximum residual diameter d_i of the indentation and contact duration T as functions of initial impact velocity V; i.e. $d_i \propto V^{\frac{1}{2}}$ and $T \propto V^{-\frac{1}{2}}$. The results are compared (approximately) with experimental evidence; agreements are satisfactory. Strain-rate sensitivity λ (defined as the ratio of impact flow-stress Y_i and static flow-stress Y_s) can be obtained easily in the proposed method, comparing the impact test results with those derived from conventional hardness measurements using the same conical indenter. Results of λ obtained by 90° and 136° indenters are reported for a wide range of materials including brittle ones, and the versatility of the proposed method is emphasized.

Y. Yamada, Japan

6059. Yoshikawa, H., and Sata, T., Measurement of tensile strength of granular brittle materials, *Scient. Pap. Inst. Phys. Chem. Res. Japan* **54**, 4, 389–393, Dec. 1960.

A method of measuring the tensile strength of granular brittle materials such as abrasive grains is proposed. Reliability of this method is examined through experiment on aluminum oxide abrasive grains. Size effect on the strength of tested materials is discussed from the point of view of Griffith crack distribution in materials. Fom authors' summary

6060. Wolters, H. B. M., and Schapink, F. W., Tensile testing machine for whiskers, *J. Sci. Instrum.* **38**, 6, 250–252, June 1961.

A screw-driven micro-tensile tester for whiskers is described. A synchronous motor moves one of the grips at a constant velocity, whereas the second grip is connected to a load cell in which a differential transformer is employed.

From authors' summary

6061. Khachiyan, M. G., A string dynamometer for measuring torsion moment (in Armenian), *Izv. Akad. Nauk ArmSSR, Ser. Tekhn. Nauk* **11**, 5, 70–71, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14745.

The principles underlying the working of the instrument are given as well as a description of the electrical scheme, and the advantages of a string dynamometer for the measurement of torsion moments are enumerated. It is pointed out that dynamometers of this type are especially convenient for the measurement of the torsion moments when high speeds of rotation are involved.

E. I. Boldyrev

Courtesy Referativnyi Zhurnal, USSR

6062. Vasil'ev, L. I., A method for varying the load in the process of deformation (in Russian), *Trudi Sibirsk. Fiz.-Tekhn. In-ta* no. 36, 83–88, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14746.

A device is described enabling a rapid change of load to be effected during testing by means of adding a supplementary load to the flexible dynamometer. A derivation is furnished for the approximate calculation formulas for the determination of this load to cover cases of testing for compression and torsion. In relation to the test conditions involved, the divergence between the calculated and the experimental results may be from 0.1 to 8%.

M. G. Gaidukov

Courtesy Referativnyi Zhurnal, USSR

6063. Frolich, R. W., Experimental investigation of effects of random loading on the fatigue life of notched cantilever-beam specimens of SAE 4130 normalized steel, NASA TN D-663, 19 pp., Feb. 1961.

Results of random-loading fatigue tests on 145 notched cantilever-beam specimens and of constant-amplitude fatigue tests on 75 similar specimens are presented. The fatigue lives for the two sets of results are compared at equal root-mean-square values of peak stresses. Compared on this basis, fatigue life was shorter for the random loading than for the constant-amplitude loading. A comparison of the random-loading results is also made with theoretical results which are based on the assumption of linear cumulative fatigue damage. The theoretical results overestimate the fatigue life over the range of stresses considered.

From author's summary

Properties of Engineering Materials

(See also Revs. 5889, 5890, 5896, 5900, 5911, 5914, 6038, 6109, 6120, 6286, 6312, 6441)

Book—6064. Hausner, H. H., Modern materials; Advances in development and applications, Vol. 2, New York, Academic Press, Inc., 1960, xv + 413 pp. $12.50.

Reviewer was amazed to learn from the first chapter of this book how many different kinds of paper can be made by the inclusion of various polymers. One useful effect is to give to a material normally bound by surface tension forces alone some degree of strength when wet. The addition of rubber engenders a range of materials suitable at one extreme for packaging chemicals and at the other for imitation leather. Perhaps the logical conclusion of such processes is reached when synthetic fibers replace the usual cellulose so that fabric substitutes can be made to replace textiles at lower cost.

Two chapters follow on special uses of ceramics. One deals with flame-sprayed coatings and is very detailed, repaying close study. The other covers the comparatively recent introduction of ceramics for cutting tools, the materials being true ceramics in contrast with the better known cemented carbides. These tools provide means for more rapid and accurate machining and are at present suited to all metals other than those combining high tenacity with high ductility. Useful recommendations on operating conditions are given.

There are two chapters on borides, one on basic factors and the second on their fabrication, properties and applications. These materials have considerable promise wherever high temperatures have to be withstood, as in rockets and gas turbines. A lengthy and authoritative chapter on titanium follows, giving a wide range of information useful to the specialist and general reader. The book concludes with chapters on welding and soldering. The former describes the many processes available for joining metals with heat, supplied either electrically or with a torch. The last chapter covers the various types of solder, their methods of use and their applications.

The several chapters of this book, all by different authors and in somewhat unequal styles, have the common characteristic of appearing to be backed by sound knowledge. The book can be recommended either for general information or for more detailed investigation of specific subjects through the references provided.

A. F. C. Brown, England

6065. Jaffe, R. I., Refractory metals, Proc. International Symposium on High Temperature Technology, Asilomar Conference Grounds, Calif., Oct. 6–9, 1959; New York, McGraw-Hill Book Co., 1960, 61–75.

Author lists 12 metallic elements as refractory metals, discusses their availability, and gives a chart for the free-world resources of these elements. He discusses the extraction, consolidation and fabrication of these elements, commenting on their low-temperature brittleness and high-temperature properties.

Review is given of alloying possibilities, oxidation, forming, joining and application. Paper includes a comprehensive statement on future developments. There are twenty-five references.

L. J. Bonis, USA

6066. Kingery, W. D., Oxides for high-temperature applications, Proc. International Symposium on High Temperature Technology, Asilomar Conference Grounds, Calif., Oct 6–9, 1959; New York, McGraw-Hill Book Co., 1960, 76–89.

6067. Trojan, P. K., Flinn, R. A., and Reese, D. J., Behavior of ductile cast iron under compressive stress, *Proc. Amer. Soc. Test. Mat.* **59,** 922–929 (Tech. Pap.), 1959.

Compressive yield strength and modulus are given for hardness from 213 to 592 Bhn.

W. H. Sparing, USA

6068. Korneev, N. I., and Skugarev, I. G., An investigation of the deformation of heat-resistant alloys on an iron and on a nickel basis (in Russian), Obrabotka splavov davleniem, Moskva, Oborongiz, 1958, 34–55; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14659.

Results are furnished of the studies carried out on the plasticity, structure and mechanical properties of modern heat-resistant alloys on an iron-nickel basis (EI 69, EI 395, EI 388, EI 481, EI 434, EI 418, EI 437 and EI 617) by varying the thermomechanical factors of the pressure treatment: the form of the stressed state, the temperatures of the deformation, the degree and velocity of the deformation. The experimental data obtained are investigated in the light of the most recent developments in metallography and of the theories of strength and plasticity of metals. Optimum conditions are drafted for the pressure treatment of individual heat-resistant alloys on the basis of the principles established in the studies.

B. I. Aleksandrov

Courtesy Referativnyi Zhurnal, USSR

6069. Krafft, J. M., and Sullivan, A. M., Influence of speed of deformation on strength properties in the post lower yield stress-strain curve of mild steel, Ship Structure Committee Rep. 127 (Contract NObs-72046), 19 pp., Dec. 1960.

6070. Klier, E. P., and Gazzara, C. P., Stress-strain properties of selected titanium metals, *Proc. Amer. Soc. Test. Mat.* **59,** 1015–1034 (Tech. Pap.), 1959.

Results are presented of measurements on specimens of three titanium metals in the plastic region, at four strain rates, and at five temperatures (−320 F to +70 F). Plots on the basis of a power law are reported to indicate regions of different deformation behavior. H. J. Grover, USA

6071. Gaidukov, M. G., and Pavlov, V. A., The creep of alloys of solid solutions: aluminium-magnesium and nickel-copper (in Russian), *Trudi In-ta Fiz. Metallov. Akad. Nauk SSSR* no. 22, 107–112, 1959; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14653.

A study was carried out on the behavior of alloys of aluminum-magnesium and nickel-copper of varying proportions in conditions producing either shearing or diffusing plastic deformation. In the region of temperature selected for each alloy the change in the character of plastic deformation was effected by variations in the temperature and the magnitudes of the acting stresses. At high stresses close to the limit of yield and at relatively low temperatures a shearing type of plastic deformation mainly took place; at low stresses and high temperatures the diffusional type of plastic deformation made its appearance, but much more rarely. The investigations on creep in aluminum were carried out at temperatures of 150 to 400° and with two stresses: 2 and 0.3 Kg/mm². The results obtained were that an increase in the magnesium content enabled a considerable lowering in the deformation and the velocity of creep in the aluminum alloys to be effected; curves are given. The investigations on creep in nickel and in alloys of nickel and copper were carried out at 500, 600 and 700° and stresses of 5 and 2 Kg/mm². Curves are furnished for the deformations and velocity of creep of these alloys and their relationship to the copper content. A short explanatory description is given of the physics of creep in alloys and the relation with the mechanism of deformation. I. L. Kats

Courtesy Referativnyi Zhurnal, USSR

6072. Arkharov, V. I., and Yakutovich, M. V., Resistance to heat and internal adsorption in polycrystalline alloys (in Russian), *Trudi In-ta Fiz. Metallov. Ural'skii Fil. Akad. Nauk SSSR* no. 19, 7–22, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14657.

General concepts are investigated dealing with the mechanical plastic deformation at low and at higher temperatures, with the internal adsorption in solid alloys, and proposals are put forward concerning the main lines of advance for increasing the heat resistance of alloys. Plastic deformation is investigated as the sum of separate elementary acts of deformation, the basis of which is to be found in the act of diffusional change of position of an atom from the node of a lattice to the nearest inter-node of the most distorted elastic region of the lattice. The principal factor influencing the diffusional mobility of the atom are the forces of the interatomic linkage. Displacements of atoms of this nature occur under the influence of temperature gradients and are directed by the applied stresses. This process is then developed along the "estafete" (carrier) by the adjacent atoms (because of the distortions introduced into the lattice by the displacement of the first atom). The perfect regions of the lattice appear to be the most suitable for the "estafete" (carrier) displacement of the atoms, while for the retarding and stoppage of this process the presence is essential of a distorted lattice. These distortions appear as prior nonhomogeneities in the lattice (destruction of the structure and incorporated matter) as well as distortions introduced by thermal fluctuations. As temperature fluctuations become more frequent, the processes of deformation become fragmentary and within the limits of deformation become purely diffusional, the cumulative effect of the spatial-provisional sequence of the acts which are not interconnected. With increase in temperature a localization takes place of the plastic deformation at the intercrystalline boundaries prossessing surplus energy, while the transition of the deformation from the boundaries to the body of the grain becomes more and more difficult. The energetic conditions contribute also to the migration of atoms in an admixture to the boundaries of the grains; the large differences in concentration of the admixtures which occur in this stage can alter the properties of a solid mixture; the mutual influence of the separate elements may result in either over-distribution of the admixture or act as a retarding agent. The theory of resistance to heat can be coupled with the study of diffusion processes, with internal adsorption and its influence of the self-diffusional mobility of atoms in regions adjacent to structural nonhomogeneities; thus, the manufacture of heat-resistant alloys appears to be a problem of selection of the optimum distribution of the optimum interacting admixtures.

V. N. Geminov

Courtesy Referativnyi Zhurnal, USSR

6073. Kuroyanagi, J., On the relation between the change in modulus of rigidity of brass wires by cold-rolling and rolling textures, *J. Phys. Soc. Japan* **16,** 5, 1019–1023, May 1961.

Pole figures for the brass specimens which had been used for the measurement of the change in modulus of rigidity in a previous investigation and had received 90 per cent reduction in cross-sectional area by cold-rolling were obtained. In the pole figure of copper, the most intense rolling texture was $\{112\} < 111 >$. In the pole figure of brass containing 10.14 per cent zinc, the most intense texture was $\{110\} < 112 >$ and the $\{110\} < 001 >$ texture also appeared in the figure in considerable degree. The intensity of the $\{110\} < 001 >$ texture increases with the increase of zinc content. The existence of the β-phase in the brass wire containing 40.24 per cent zinc was ascertained, which had been predicted previously. On the basis of these results the variation in the modulus of rigidity of the specimens, 57.5 per cent cold-rolled, with various zinc contents was investigated.

From author's summary

6074. Sobolev, Yu. S., Investigation of a wood's elasticity constants (in Russian), *Naucbn. Dokl. Vyssb. Sbkoly. Lesoinzb. Delo* no. 4, 173–177, 1958; *Ref. Zb. Mekb.* no. 10, 1959, Rev. 12806.

Determinations were made by an experimental method of the moduli of elasticity E and of the coefficients of the transverse deformation of pine wood in all the principal directions of elastic symmetry and in the direction across the fibers at an angle of 45° to the annual layer. The moduli of shear G in the planes of symmetry were computed by these data. The object of the investigation was to establish the relation of the magnitude of the elastic constants to the dimensions of the samples. Three sets of samples of square section and with sides 3, 6 and 12 cm were tested. The radius of the annual layer was 10 cm everywhere, consequently the angles of slope of the faces of the samples to the radii of the annual rings differed. The deformations were measured by means of wire strain gages. With increase in the dimensions of the sample, modulus E_a decreased inappreciably, while moduli E_t and E_r decreased by 1.5 and 2 times. The latter is explained by the marked curvature of the annual rings in large radial and tangential samples where any scheme of orthogonal anisotropy is no longer applicable. As the dimensions of the sample increase the differences between the elastic constants for different directions across the fibers are smoothed out and a better case is made available for the application of a scheme of transverse isotropy. Coefficients for μ were obtained with wide divergencies. The conditions of reciprocity in the elastic constants are fulfilled with divergencies of from 10 to 35%. The influence

of the dimensions is more strongly marked in the case of the moduli E than in the magnitudes μ and G in the principal directions and than in the magnitudes E and μ in directions making an angle of 45° with the annual rings of the wood.

E. K. Ashkenazi
Courtesy Referativnyi Zhurnal, USSR

6075. Ivanyan, V. M., The theory of creep of vulcanized natural rubber (in Armenian), *Izv. Akad. Nauk ArmSSR, Ser. Fiz.-Mat. Nauk* **11**, 2, 51–58, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14709.

The following equation is based on experimental data for creep and relaxation of vulcanized natural rubber

$$\frac{d\sigma}{dt} = \lambda E \frac{d\varepsilon}{dt} \exp(\lambda \varepsilon) - Aye^{\varepsilon} \exp(-\gamma t) \qquad [*]$$

where σ is the stress, ε the deformation, λ, E, A, γ the visco-elastic constants of the material. The solution of equation [*] for particular cases of relaxation with ε = const and of creep under the action of a constant force gives relationships which satisfy the experimental data.

Remarks by the abstractor. Equation [9] on p. 54, should follow from formula [8] and the numerical values for the parameters brought in by the author should have a somewhat different form. The solution given in the paper appears to contain an error because the expression after the logarithmic sign is negative.

N. I. Malinin
Courtesy Referativnyi Zhurnal, USSR

6076. Bayuk, E. I., The investigation of the elastic properties of rock samples taken from a deep borehole at high pressures, *Bull. Acad. Sci., USSR, Geophys. Ser.* no. 12, 1173–1177, Dec. 1960. (Translation of *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 12, 1756–1761, Dec. 1960 by Amer. Geophys. Union, Washington 5, D. C.)

The elastic parameters of rocks taken from the Novo-Alekseevskaya deep borehole were determined by the supersonic impulse method under pressures up to 4000 kG/cm². The obtained values of the velocities of longitudinal waves are compared to the data of the seismic logging of the above-mentioned borehole.

From author's summary

6077. Blizard, J. R., Properties and applications of glasses and ceramics, *Mach. Design* **33**, 14, 166–167, 169, July 1961.

6078. Warburton, F. L., James, J. F. P., and Hother-Lushington, Miss S., Some visco-elastic properties of nylon, *Brit. J. Appl. Phys.* **12**, 5, 230–237, May 1961.

Structures: Simple

(See also Revs. 5924, 5939, 5953, 5955, 5960, 6003, 6028, 6029, 6035, 6122)

6079. Yusuff, S., Design for minimum weight—considerations based on the long wave instability of stiffened plates in compression, *Aircr. Engng.* **32**, 380, 288–294, Oct. 1960.

Paper is a continuation of an analysis presented by the author in August 1958 issue of *Journal of Aero/Space Sci.* [AMR **12**(1959), Rev. 1778]. The present problem is that of minimum weight design of stiffened compression panels having either Z-section or integrally machined unflanged stiffeners. The design criterion is based primarily on a plate instability mode in which the plate and stiffeners buckle simultaneously over a length equal to the pin-ended length of the panel, after being subjected to equal stress. Other types of instability are discussed but are not considered critical for the types of panels commonly used in aircraft construction. Mention is made of the applicability of the theory to panels having supporting ribs, but the reviewer cannot see where the effect of such ribs is accounted for in the theory. Graphs and tables are presented which will be of interest and use to designers of such structures. M. E. Raville, USA

6080. Garden, R. J. P., Analysis for moments and deflexions in the elastic-plastic range, *Proc. Instn. Civ. Engrs.* **16**, 157–170, June 1960.

Author introduces "commuted curvatures", i.e. curvatures due to plastification in addition to those occurring by unlimited validity of Hooke's law, and he uses them as elastic weights. Floating body analogy as an antithesis to column analogy in the elastic case, established in an earlier paper of the author, supports this idea. If cross section and stress-strain relation are given, commuted curvatures may be calculated and plotted in diagram depending on relation M/M_p, M_p being full plastic moment. Method is carried out for rectangular cross section and idealized elastic-plastic material (steel without strain-hardening). Use is shown for two miniature test portal frames. Finally, extension of method is indicated to take into account strain-hardening, haunching effects, axial loads and variable cross sections.

W. Mudrak, Austria

6081. Soether, K., The structural membrane, *J. Amer. Concr. Inst.* **32**, 7, 827–850, Jan. 1961.

Author defines a structural membrane as a compression-carrying structural element formed by fusing two or more of the following three geometrical shapes into a continuous surface: the parabolic elliptical dome, the hyperbolic paraboloid, logarithmic elliptical funnel. The structural membrane is an approximation to the ideally shaped elastic membrane.

Three examples of elastic membranes and their corresponding structural membranes are discussed at some length. The first example is that of an elastic membrane spanning a circular opening and subjected to uniform pressure; the corresponding structural membrane is a parabolic dome. The second example is that of an elastic membrane over a square opening subjected to a uniform load acting upward and a central concentrated load acting downward; the corresponding structural membrane consists of a logarithmic circular conoid in the central region and hyperbolic paraboloids in the four corners. The last example is that of an elastic membrane over a square opening subjected to upward acting uniform pressure and four symmetrically placed downward acting concentrated loads. In this case the elastic membrane is represented by a more complicated combination of the three geometrical shapes mentioned previously.

A section is devoted to a discussion of edge loads on structural membranes, and the paper is concluded with a discussion of some of the relative advantages and disadvantages connected with the use of structural membranes.

M. E. Raville, USA

6082. Mitnik, G. S., Deformation of prestressed concrete slabs due to the eccentricity of the prestressing steel (in Russian), *Beton i Zhelezobeton* **12**, 572–576, Dec. 1960.

In said slabs of rectangular shape, the effect of eccentricity of prestressing steel is regarded as equivalent to that of uniform bending couples applied along the edges. For an unsupported slab the deflection $w(x,y)$ is then a second-degree polynomial in x and y (classical plate theory). This is also the case whenever the rigidities in the two principal directions are not equal (orthotropy).

Author treats one example of the isotropic case and one of the orthotropic case. In the latter one the rigidities are evaluated by means of formulas given by J. M. Rippenbein, in *Stroitelnaja*

Mekhanika i Rascbet Sooryzbenii, no. 3, 1960, for hollow slabs with cavities running parallel to one of the principal directions. Formulas are reproduced in paper for cavities of circular, elliptical, and rectangular with rounded corners, cross section.

In the example treated, cavities are circular and the required integration is performed numerically. Results show the increased deflection imputable to the cavities in the slab.

G. H. Beguin, Switzerland

6083. Shkerbelis, K. K., Influence of a complex load on the deformation of concrete (in Russian), Issled. po Betonu i Zhelozobetonu, Vol. 3, Riga, Akad. Nauk, LatvSSR, 1958, 57–60; *Ref. Zb. Mekb.* no. 11, 1959, Rev. 14188.

Results are given of the tests on thin-walled concrete tubes for compression followed by torsion. It is noted that with increase in the preliminary peripheral compression from 0 to 35.9 kg/cm^2 the strength of the concrete to shear when followed by torsion increases by 1.54 times in comparison with torsion of samples not so treated. When the compression forces are constant the increase in the torsional moment produces a complementary hardening of the sample. A. M. Zhukov made similar observations on phenomena produced in tests on the complex loading of steel tubes [*Izv. Akad. Nauk SSSR, Otd. Tekb. Nauk* no. 11, 53–61, 1954]. From the very moment of the start of torsion on the curve $\sigma_i - e_i$ a characteristic fracture appears, due to the turning of the principal axes of the stresses. The testing apparatus, the measuring devices and the procedure adopted for carrying out the experiments were described in a previously published article [A. K. Malmeister, K. K. Sherbelis. In: Investigations on concrete and ferroconcrete, 2, Riga, Akad. Nauk LatvSSR, 1957, 127–139].

B. A. Berg

Courtesy Referativnyi Zhurnal, USSR

6084. Farber, S. J., Some questions relating to the deformation of concrete when taking account of the temperature factor (in Russian), Teoriya Rascheta j Konstrair. Zhelezobeton. Konstruktsii; Moskva, Gosstroiizdat, 1958, 187–200; *Ref. Zb. Mekb.* no. 11, 1959, Rev. 14448.

The problem is investigated of the spreading of heat in concrete with consideration for its change of state occurring in the course of heating. An analytical expression of the shifting boundary of division between the humid and the dry concrete is given in relation to the changes of thermal capacity in its different layers and the latent heat of vapor formation. The value was found of the depth of the zone of division with varying values for the temperature of the heat source and the time used for heating. An approximation of the temperature function required is sought for by the method of orthogonalization in the form of a generalized Bubnov-Galerkin equation. Experimental and theoretical magnitudes of the relative deformations of concrete cylinders are compared in relation to temperature and the velocity of heating. The experiments show that the velocity of heating and the age of the concrete exercise material influence in the deformation. It is noted that with intense irregular heating aftereffect deformations are produced in the concrete.

V. V. Pinadzhyan

Courtesy Referativnyi Zhurnal, USSR

6085. Pirozhkov, G. I., The effect of shrinkage in a concrete slab connected to girders (in Russian), *Trudl Novosib. In-ta, Inzb. Zb.-d. Transp.* no. 13, 48–85, 1958; *Ref. Zb. Mekb.* no. 11, 1959, Rev. 14467.

A method is described for the calculations of a symmetrical section consisting of two reinforced concrete slabs and of a metallic girder connecting the slabs; the method is based on a proposition by K. K. Yakobson [*Tr. Novosib. In-ta Inzb. Zb. d. Transp.* no. 11, 323–330, 1955]. Experimental data are furnished for verification of the character of the changes in deformations with time, with a parallel evaluation of the free deformations of the slab under different conditions of relative humidity. The relative deformations of the shrinkage of the slabs over a period of 548 days were 4.9–6.9 mm. The deformations of composite beams were appreciably less than the deformations of free beams. A recommendation is made to take the full deformation due to shrinkage (with a humidity of 70%) as equal to 4×10^{-4} in the calculations. A nomogram is proposed for the determination of the extent of creep. The modulus of elasticity is assumed to be constant, equal to the initial modulus with momentary deformations due to compression.

A. E. Desov

Courtesy Referativnyi Zhurnal, USSR

6086. Mathey, R. G., and Watstein, D., Investigation of bond in beam and pullout specimens with high-yield-strength deformed bars, *J. Amer. Concr. Inst.* **32,** 9, 1071–1090, Mar. 1961.

Bond strengths were determined in 18 beam and 18 pull-out specimens with deformed reinforcing bars having a nominal yield strength of 100,000 psi. The lengths of embedment ranged from 7 to 17 in. for #4 bars and from 7 to 34 in. for #8 bars. The bond strength was found to decrease with increases in the length of embedment for a bar of a given size. The bond also decreased with an increase in the bar diameter for a given length-diameter ratio. Bond failures were obtained in all beams containing #8 bars; with #4 bars, both tensile and bond failures were observed.

The ultimate bond stresses in the pull-out specimens agreed in general with the values obtained in beams with #4 bars. However, for #8 bars the bond strengths in pull-outs were significantly greater than the values obtained with beams.

It was found advisable to use either a loaded-end slip of 0.01 in. or a free-end slip of 0.002 in. to define "critical" bond stresses, depending on which of these slips developed first. Bond stresses corresponding to these values of slip were sufficiently low to insure that under-reinforced beams designed on the basis of these criteria would fail by yielding of reinforcement.

From authors' summary

6087. Jain, O. P., Ultimate strength of reinforced concrete arches, *J. Amer. Concr. Inst.* **32,** 6, 697–713, Dec. 1960.

When load on a two-hinged arch is increased so as to produce plastic deformations in area of maximum bending moments the horizontal thrust starts increasing at a faster rate than elastic theory would predict. Resulting reduction in maximum moments causes substantial increase (50 to 100%) in ultimate load capacity.

Theory presented by author is based on idealized stress-strain curve of concrete and actual stress-strain curve of steel reinforcements. Ultimate load capacities and deflections predicted by theory agree very well with test results.

A. F. Foerster, USA

6088. Gee, A. F., Elastic analysis of a symmetrical fixed-ended arch of varying section, *Civ. Engng., Lond.* **55,** 653, 1575–1581, Dec. 1960.

Standard equations for the analysis of symmetrical fixed-ended arches of varying section were programmed for the Ferranti Pegasus Computer to facilitate the derivation of influence lines for such structures. Details of the analysis and of the program are given.

P. Seide, USA

6089. Pippard, A. J. S., and Chitty, Letitia, Stresses and deformations in elastic frames, *Proc. Instn. Civ. Engrs.* **16,** 171–188, June 1960.

Deducing truss bar forces from equilibrium condition for the nodes on the one hand and from the node deflections on the other,

authors get a set of condition equations. From these equations all deflections may be calculated, whether the frame is statically determinate or not. Method is explained by practical examples showing applicability to space frames and is used to deduce influence lines.

Reviewer believes using this method in case of the last example may cause errors, since the two ties counterbracing center panel are supposed to work only alternately. According to it, truss is of variable structure and superposition law is not valid.

W. Mudrak, Austria

6090. Allen, D. N. de G., and Severn, R. T., Composite action between beams and slabs under transverse load, *Struct. Engr.* **39,** 5, 149–154, May 1961.

The problem considered is that of a slab with identical spanwise beams repeated at equal intervals and supported over several transverse supports. This is ordinarily a complex three-dimensional problem and simplifying assumptions are usually made to solve it. The authors develop a solution by considering the slab and beams as acting independently and then to act together by forcing the common boundary conditions to be compatible. The analysis is written for solution by computer. Although certain small approximations in the analysis still exist, their effect is negligible compared with a rigorous solution.

A. G. H. Dietz, USA

6091. Starzewski, K., Analysis of frames with V-supports, *Concrete Constr. Engng.* **56,** 4, 141–145, Apr. 1961.

6092. Poppleton, E. D., The redesign of redundant structures having undesirable stress distributions, *J. Aerospace Sci.* **28,** 4, 347–348 (Readers' Forum), Apr. 1961.

6093. Nitetskaya, I. B., Distribution of normal stresses in the flanges of double T-beams (in Russian), *Sb. Naucbn. Trudi Leningr. Inzb.-Stroit. In-ta* no. 29, 182–188, 1958; *Ref. Zb. Mekb.* no. 10, 1959, Rev. 12421.

An investigation is carried out on the distribution of normal stresses over the width of the flange B of double T-beams by means of the method of dismembering them into five plates and applying to the investigation the stresses already known in them from solutions in the theory of elasticity. The comparison of the numerical results with the experimental data for the special case of a beam freely supported at the ends and loaded with a concentrated load at the center of the span showed a divergence of 5–9% at the web end; of 10–20% at the edge of the flange. In the case of a beam with ratios of the dimensions generally adopted in constructional work, freely supported along the edges and with an evenly distributed load, the fact was established that the distribution of the normal stresses over the width of the flange can be looked upon as uniform. The influence was then examined of the dimensions of the beam on this distribution, when it was established that lack of uniformity in the distribution increased sharply with $l/B \leqslant 5$ (l being the length of the span) while with $l/B \geqslant 25$ the distribution of the stresses in question could be considered uniform. Under the conditions of the investigation, the height of the web of the beam and the relation of the thickness of the web to the thickness of the flange influenced the uniformity of distribution far less than the relation l/B.

N. P. Beresnev

Courtesy Referativnyi Zhurnal, USSR

6094. Zevakhin, O. K., Bending of a cantilever of rectangular section, made up from three transversally-isotropic layers, subjected to the action of a transverse force applied to the unstiffened end (in Russian), *Izv. Leningrad Elektrotekbn. In-ta* no. 35, 252–266, 1958; *Ref. Zh. Mekb.* no. 11, 1959, Rev. 13994.

The bending by a transverse force is investigated of a rectangular cantilever, consisting of three transversally-isotropic layers. The materials concerned are cemented together, the height of the outer layers and their elastic constants are equal, tangential forces are not in evidence on the upper, lower and lateral faces while at the interface of the layers the stresses and displacements are continuous. In the outer layers

$$\sigma_x^{(j)} = \sigma_y^{(j)} = \tau_{xy}^{(j)} = 0, \quad \tau_{xz}^{(j)} = \frac{\partial \Psi_j}{\partial y}$$

$$\tau_{yz}^{(j)} = -\frac{\partial \Psi_j}{\partial x} - \frac{1}{2} C^{(j)} (y^2 - b_1^2)$$

$$\sigma_z^{(j)} = C^{(j)} y z \quad (j = 1, 1')$$

while in the middle layer

$$\sigma_x^{(0)} = \sigma_y^{(0)} = \tau_{xy}^{(0)} = 0, \quad \tau_{xz}^{(0)} = \frac{\partial \Psi_0}{\partial y}$$

$$\tau_{yz}^{(0)} = -\frac{\partial \Psi_0}{\partial x} - \frac{1}{2} C^{(0)} (y^2 - b^2) + D$$

where $2b_1$, $2a$, l are the dimensions of a rectangular cantilever, $C^{(j)}$, D the constants being sought, while $\Psi_j(x, y)$ is a function satisfying the equation

$$\frac{\partial^2 \Psi_j}{\partial x^2} + \frac{\partial^2 \Psi_j}{\partial y^2} + \frac{C^{(j)} \sigma j}{1 + \sigma_j^x} = 0 \quad (j = 0, 1, 1') \qquad [1]$$

The solution of equation [1] is looked for in the form

$$\Psi_j = \sum_{k=1}^{\infty} \left[A_{jk} s\, b \frac{k\pi y}{a} + B_{jk}\, cb \frac{k\pi y}{a} - \frac{4 C^{(j)} \sigma\, j\, a^3 (-1)^k}{\pi^3 (1 + \sigma_j) k^3} \right] \times$$

$$\times \sin \frac{k\pi x}{a} \quad (j = 0, 1, 1') \qquad [2]$$

where A_{jk}, B_{jk} are the constants being sought which are determined from the boundary conditions. The following limits $\sigma_1 = \sigma_1' = \sigma_0$ are imposed on the Poisson coefficients from the condition of continuity for the transposition, while for the constants $C^{(j)}$ the following values are obtained from the face conditions

$$C^{(0)} = -\frac{P \mu_0}{J_0 \mu_0 + 2 J_1 \mu_1}, \quad C^{(1)} = -\frac{P \mu_1}{J_0 \mu_0 + 2 J_1 \mu_1} = C^{(1')}$$

From the condition of continuity of the tangential stresses on the boundary emanates

$$D = \frac{P (b_1^2 - b_0^2) (\mu_0 - \mu_1)}{2 (J_0 \mu_0 + 2 J_1 \mu_1)}$$

where P is the magnitude of the deflection force, J_0, J_1 are the moments of inertia of the transverse sections corresponding to the middle and outer layers relatively to the axis, parallel to the axis 0_x.

A. K. Rukhadze

Courtesy Referativnyi Zhurnal, USSR

6095. Prikov, M. M., Calculations for the forces and the deformations of steel girders when taking into account the formation of plastic hinges (in Russian), *Trudi Rostovsk. -n/D Inzb. Stroit. In-ta* no. 6, 187–213, 1958; *Ref. Zb. Mekb.* no. 11, 1959, Rev. 14176.

Practical methods are proposed for the calculations of the forces and deformations of single-span and continuous girders when deflected elasto-plastically. The girders have various loading schedules and spans of various lengths. The limiting deflection moment of the girder is found from the condition of equalization of the moments in the span and in the supports. Girders are

examined with constant and variable sections. When determining the deformations (deflections) beyond the limit of elasticity, consideration is given to the presence of elasto-plastic zones along the length of the girder. The well-known method is used for the determination of the deflection in a given section by the moment's area on the elastic portions and from the assigned moment's area on the extension of the yield zone. The author limits the scope of his paper by restricting himself to detailed accounts of the determination of the lengths of the elasto-plastic portions, the calculations for the assigned moments, the finding of the moment's area and its center of gravity and, finally, the obtaining of the girder's deflections, loaded by evenly distributed loads as well as by concentrated forces. A. I. Strel'bitskaya

Courtesy Referativnyi Zhurnal, USSR

6096. Woeber, W. A., Wind structure and the assessment of wind loads, *Struct. Engr.* **39,** 5, 155–162, May 1961.

6097. Hewlett, P. M., Position of planes of contraflexure due to wind on multiple-storey buildings, *Concrete Constr. Engng.* **56,** 2, 57–63, Feb. 1961.

Structures: Composite

(See also Revs. 5961, 5970, 5973, 5978, 5981, 6113, 6213, 6355)

6098. Gerard, F. A., Calculation of flexure and torsion in plates and hyperbolic paraboloidal shells, using a digital computer, *Trans. Engng. Inst. Canada* **4,** 3, 7 pp., 1960.

Author considers application of method of finite differences, in conjunction with classical plate theory, to solution of boundary-value problems for flat plates and shallow hyperbolic paraboloidal shells in which the generators can be regarded as approximately orthogonal. His main claim for originality of approach rests on his method of dealing with mixed boundary conditions such as encastré and free edges and corners, and he refers to the reviewer's original outline in *J. Roy. Aero. Soc.* June 1954 [AMR **7**(1954), Rev. 3990].

He has unfortunately not seen reviewer's complete later treatment of this problem, in which not only straight edges and orthogonal corners were dealt with but also plates of irregular planform and varying thickness as well as the effect of shear displacements. In this treatment is also included a method of matrix formulation that includes u and v displacements as well as the w displacements alone considered by the author. The w and v displacements in the plane of the middle surface were included by reviewer not for application to solid plates, where they are unimportant, but to deal with wings having interior bracings of spars and ribs. This work appeared first as R.A.E. Technical Notes nos. Str. 168 (March 1955) and 209 (November 1956), and were finally published as Aero. Res. Council R. & M. no. 3048 (1959) under the title "A general method (depending on the aid of a digital computer) for deriving the structural influence coefficients of aeroplane wings." The method is also described in the reviewer's book "An introduction to the theory of aircraft structures" (Edward Arnold, June 1960). D. Williams, England

6099. Khosla, A. N., Shell roof for 325-foot auditorium span at the University of Roorkee, Proceedings of the Fifth Congress on Theoretical and Applied Mechanics, Univ. of Roorkee, Roorkee, India, Dec. 23–26, 1959; Kharagpur, Indian Soc. of Theor. and Appl. Mech., A. 1-A. 34.

Author presents design and structural analysis of a large span thin-shell reinforced-concrete roof. The inverted catenary arch is approximated by straight line sections. Column analogy method was used in the analysis of the arch. A typical 9-ft section is considered in the analysis. Author neglects secondary bending moments due to eccentricity of thrust in the straight sections approximating the catenary. These moments are of same order of magnitude as those considered in the paper. The study of stability of buckling characteristics of the arch should also be added for completeness of the paper. L. W. Smith, USA

6100. Cheng, S.-Y., Stress analysis of rigid frame bridges with inclined legs, *Proc. Amer. Soc. Civ. Engrs.* **86,** ST 12 (*J. Struct. Div.*), 1–22, Dec. 1960.

This paper presents formulas for a direct solution by moment distribution of symmetrical rigid frames with inclined legs. The frames considered have columns with both hinged and fixed ends. The actual frames discussed have also horizontal beams which are either continuous with or are hinged to the frames at the point of connection of the columns to the girder. All frames are symmetrical and are prismatic throughout. The stiffnesses carry-over factors are tabulated for each type of frame considered. The fixed end moments are also shown both for vertical and horizontal loads. The loadings are considered as a combination of symmetric and antisymmetric ones resulting in a simplified procedure for obtaining influence lines.

The paper includes four numerical examples for the determination of fixed-end moments for horizontal and vertical loads as well as shrinkage of the deck. The fifth numerical example is on the determination of influence lines for moment in one of the frames considered. The paper also includes an appendix giving the expressions for stiffnesses, carry-over factors and fixed-end moments for frames which have different sections.

The paper does not represent any novel approach to the problem of analysis, nevertheless, it is a useful source for a simple and rapid analysis of the types of frames considered.

N. Khachaturian, USA

6101. Theilheimer, F., and Starkweather, W., The fairing of ship lines on a high-speed computer, David W. Taylor Mod. Basin Rep. 1474, 21 pp., Jan. 1961.

Assuming that offsets of a small number of points on hull surface are taken from a preliminary design, method is presented for using computer to interpolate offsets for arbitrarily large number of points. Authors choose spline curves to represent ship lines, such curves reducing to a single cubic between initial division points. The analogy between such curves and a thin beam or spline simply supported at a finite number of points displaced from a straight line is pointed out. Authors introduce computational criterion for detection and correction of unwanted fluctuations. J. E. Goldberg, USA

Book—6102. Otto, G., Aircraft fuselage shell structures [Rumpf Schalen- und Vollwandbauweise, Vol. 1; Moderne Leichtbautechnik im Flugzeugbau und weiteren Anwendungsgebieten], Braunschweig, Friedr. Vieweg & Sohn, 1960, xii + 284 pp. DM 24.80.

This book undertakes to present the more important existing material on design and construction as practiced by the aircraft industry today. It is written for the young German engineer, and its purpose is to give a concise, if somewhat abbreviated, practical knowledge of the airplane and its individual components. The book includes most of the important fundamental calculations needed for daily use. In addition there are included numerous tables, numerical examples, as well as abstracts from theoretical and experimental reports, all of which should be of use to the structural engineer.

The author is to be congratulated on the abundance of figures which supplement the text. Although there are some topics which

are treated rather briefly, the addition of the illustrations should enable the person with limited experience in the field to understand the material covered.

The first two chapters of the book consist primarily of portions of the Civil Air Regulations and the Bauvorschriften für Flugzeuge. These are included to familiarize the reader with the loads experienced in flight and the requirements for obtaining a license for the airplane. The third chapter deals with the calculation of the loads experienced by the supporting structure in flight and landing conditions.

The fourth chapter analyzes the stresses occurring in the various individual components of the airplane. In approximately 100 pages the author covers the ring shell structure, spar stress due to bending, moments of inertia, symmetrical and unsymmetrical bending, shear stresses and shear flow in open and closed cells.

The last chapter deals with various construction configurations and fabrication methods including analysis of rivets and welds. A section on column behavior is included in which the usual buckling formulas are presented. The concept of effective width is discussed and methods for calculating the critical stress are presented.

The book is intended to acquaint the German engineer with present day knowledge of the requirements and techniques of aircraft structures, and it accomplishes this purpose. An engineer experienced in the field would find the book useful and for a person with limited experience it would be of great value. However, a person with knowledge of the English language has access to almost all of the material in this book covered in much greater detail in the numerous texts written in English.

J. N. Perkins, USA

6103. Mansfield, E. H., Combined flexure and torsion of a class of heated thin wings: a large-deflection analysis, Aero. Res. Counc. Lond. Rep. Mem. 3195, 29 pp., 1961.

This paper presents a large-deflection analysis for combined flexure and torsion of solid or hollow wings of biconvex section with a parabolic chordwise temperature distribution. The analysis embraces the buckled, as well as unbuckled, regimes.

From author's summary

6104. Ponsford, H. T., Wood, R. M., Lowe, R. E., and Madewell, J. F., Thermostructural design—entry vehicles for Mars and Venus, *ARS J.* **31**, 4, 474–481, Apr. 1961.

Authors present a method for designing insulated structures for astronautical vehicles entering planetary atmospheres, using the Martian and Venusian missions as examples. A review of the performance, flight mechanics, and thermodynamics of the structures is the basis for computing transient temperatures for various insulation arrangements. Using known criteria for elevated temperature modulus, strength and density of structural materials, the authors present a variety of possible structural configurations. Combining the thermal with the structural results, the vehicle weight is related to the peak temperature. This relation exhibits a minimum-weight region, permitting a specific choice of a least-weight structural configuration and materials for a chosen mission.

The paper is novel in its usage of the "total system" approach in the structural design of astronautical vehicles that results in designating promising insulation and structural materials, and desirable configurations.

G. A. Hoffman, USA

6105. Baron, F., Matrix analysis of structures curved in space, *Proc. Amer. Soc. Civ. Engrs.* **87**, ST 3 (*J. Struct. Div.*), 17–38, Mar. 1961.

A general solution is given in matrix form for the analysis of a member curved or segmental in space and continuous between two supports. The member may be loaded in any direction.

The solution also yields a general slope deflection equation which involves a stiffness matrix. The stiffness matrix contains all stiffness and carry-over factors for the ends of the member.

From author's summary by D. Williams, England

6106. Gerstle, K. H., Flow graphs in structural analysis, *Proc. Amer. Soc. Civ. Engrs.* **86**, ST 10 (*J. Struct. Div.*), 125–137, Oct. 1960.

Author presents the basic properties and operations of "flow graphs" which are a pictorial method of illustrating the functional dependence between sets of variables and which have been previously used in feedback theory and other electronic applications. Several examples of the application of flow graphs to the solution of continuous beams are given which indicate that the method has potential in the field of statically indeterminate structural analysis as a means of obtaining simplified yet completely equivalent structures for purposes of stress analysis.

J. E. Breen, USA

Machine Elements and Machine Design

(See also Revs. 5835, 5836, 5840, 5847, 5892, 5938, 5940, 5994, 5999, 6009, 6054, 6438)

6107. Wetzel, S., Simplified methods of design of the six-link dwell mechanism (in German), *Maschinenbautechnik* **9**, 12, 655–661, Dec. 1960.

For a six-link mechanism consisting of a four-bar linkage, a floating link attached to a point on the coupler, and an output crank (or rocker) driven by the floating link, author derives straightforward graphical constructions leading to an approximate dwell of the output link for up to six prescribed positions of the input crank and permitting, if desired, relatively long periods of approximate dwell.

F. Freudenstein, USA

6108. Bushuev, L. P., Motion of the load in a tumbler in a planetary central mill (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 167–169, Jan./Feb. 1961.

6109. MacDonald, R. J., Development of iron-base seal materials for high temperature application, *ASLE Trans.* **4**, 1, 12–19, Apr. 1961.

This paper describes an experimental investigation of materials for use as high-temperature rubbing seals.

The results of a comprehensive evaluation of the rubbing properties of commercial high-speed tool steels are presented. It is shown that molybdenum steels have desirable high-temperature seal characteristics. Tungsten steels, on the other hand, exhibit inferior properties. The best over-all performance is demonstrated by a steel containing both molybdenum and tungsten in combination with cobalt.

These commercial tool steels are not effective over 1000F; therefore, new material combinations were sought. Using powder metallurgy techniques, a series of iron-base alloys containing molybdenum and cobalt was studied. It was found that alloys containing from 5 to 20% of both molybdenum and cobalt exhibit excellent rubbing properties up to 1200F and, in general, are superior to the tool steels tested.

Further testing of Fe-Mo-Co materials revealed that friction and wear are markedly dependent upon the test conditions. A minimum coefficient of friction was obtained with the highest surface speed (150 fps) and with the highest ambient temperature (1200F).

The desirable rubbing properties of this family of materials are explained in terms of surface oxidation products which act as solid-film lubricants during high-temperature rubbing.

From author's summary

6110. Boehm, J., Hermann, A. L., and Blanche, J. F., Transmission device for reversibility of rotation with extremely fast action, NASA TN D-603, 28 pp., May 1961.

6111. Kuklin, V. B., Reshetov, D. N., and Shuvalov, S. A., Analysis of a coupling with annular grooves (in Russian), *Vestnik Masb.* 40, 9, 19–23, Sept. 1960.

6112. Brovman, M. Ya., **Determination of forces between rolling gear teeth** (in Russian), *Vestnik Masb.* **40**, 9, 36–38, Sept. 1960.

Fastening and Joining Methods

(See also Revs. 6038, 6064)

6113. Masubuchi, K., Analytical investigation of residual stresses and distortions due to welding, *Welding J. Res. Suppl.* 39, 12, 525-s–537-s, Dec. 1960.

Contents of this paper seem to be best summarized by the author's final conclusions, as follows: "An attempt has been made to develop an analytical method of studying residual stresses and distortions caused by welding. The investigation has been particularly aimed at developing an analytical study which can be applied to such problems of practical importance as the determination of residual-stress distribution in various types of joints and the investigation of the influence of welding procedures on residual stresses and distortions. The concept is based on an analogy between the theory of residual stresses in metals and the theory of the vortex motion of fluids. An analytical method similar to Prandtl's wing theory in aerodynamics has been developed.

"Experimental as well as theoretical studies were conducted. On the basis of the analytical investigation of experimental results, physical models suitable for various types of joints were established. The effects of various welding procedures on residual stresses and distortions also were studied."

Paper is interesting, and seems to give a comprehensive account of author's researches, comprising some 12 pages, 17 figures and 33 references. J. M. Alexander, England

6114. Makarov, L. O., A simple technique of ultrasonic cold welding, *Soviet Phys.-Acoustics* 6, 4, 507–508 (Brief Comm.), Apr./June 1961. (Translation of *Akust. Zh., SSSR* 6, 4, 507–508, Oct./Dec. 1960 by Amer. Inst. Phys., New York, N.Y.)

6115. Tindall, R. B. L., A recent solution to the problem of stress relieving of welds under site conditions, *So. African Mech. Engr.* 10, 6, 141–146, Jan. 1961.

6116. Gabrielli, G., Theory and practice in designing riveted joints for aeronautical structures (in Italian), *Aerotecnica* 39, 6, 269–288, Dec. 1959.

6117. Kudryavtsev, I. V., and Naumchenkov, N. E., The fatigue strength of welded joints in large-size steel castings when using heavily-coated electrodes (in Russian), *Svarochnoe Proiz-vo* no. 1, 4–9, 1959; *Ref. Zh. Mekb.* no. 11, 1959, Rev. 14546.

The strength was studied of the welded joints of cast steel mark St. 35L, made by means of welding with heavily-coated electrodes. The investigation was carried out on cylindrical cut-out samples with account being taken of the scale factor and the role played by the thermal treatment. The welding of the plates with a thickness of 330 mm was carried out by means of a wire Sv-10 G2 with a diameter of 3 mm, using a flux AN-8. The seam was situated along the middle of the sample. The experiments were made on the basis of 10 million cycles. It was established that welded joints of steel mark St. 35L have limits of strength not lower than the corresponding limits of the basic metal (7.5–11 Kg/mm^2). The values for the limits of strength of St. 35L are lower than that of rolled steel mark St. 22K and cast steel mark St. 20GSL. Samples with a diameter of 200 mm have a limit of strength 35% lower than samples with a diameter of 20 mm. This bears out the expediency of using cast steel mark 20 GSL for appropriate welded joints.

V. D. Kodolov

Courtesy Referativnyi Zhurnal, USSR

6118. Gladkovskii, V. A., Riveting of metals under hydrostatic pressure (in Russian), *Fiz. Metallov i Metallovedenie* 6, 4, 761–762, 1958; *Ref. Zh. Mekb.* no. 10, 1959, Rev. 12670.

An experimental investigation was carried out on the influence of riveting, by tension in conditions where hydrostatic pressure up to 3500 kg/cm^2 is acting on the mechanical properties of steel mark St50 (quenched and tempered at 700°), on Cu (annealed at 600°) and beryllium bronze (quenched at 800°). To start with, the test samples were lengthened up to different magnitudes of deformation with simultaneous action of hydrostatic pressure and were then tested at atmospheric pressure for single axis tension on an IM-4R machine. It was established that hydrostatic pressure has no influence on the riveting characteristics of steel mark St 50 and of Cu. In the case of beryllium bronze its capacity for concentrated plastic deformation and resistance to disruption increased appreciably with increase in the extent of riveting. Thus, if in ordinary conditions the destruction of the test sample takes place at 80% deformation then, with pressure at 2000 kg/cm^2 a deformation of 96% can be attained. An X-ray structural analysis showed that riveting bronze under pressure is accompanied by a few large increases in the parameter of the lattice which is not the case when the riveting is done in normal circumstances. The toughening effect of hydrostatic pressure in riveting is linked up with residual stresses and anisotrophy which appear in the process of quenching. The influence of phase conversions (the separating out of the γ-phase) is of a negative character as hydrostatic pressure ordinarily retards the development of conversions taking place with increase of volume. V. N. Geminov

Courtesy Referativnyi Zhurnal, USSR

6119. Danilov, V. K., Determination of the coefficient of loading and of the distribution of stresses in the joint when designing joints united by threaded screws (in Russian), *Inzbener.-Fiz. Zh.* 1, 8, 65–72, 1958; *Ref. Zh. Mekb.* no. 11, 1959, Rev. 14539.

The distribution of stresses and the coefficient of loading in a stressed screwed union of two parts without the use of a gasket is studied by investigating the stressed state of a plate of small thickness, lying in an arbitrary meridianal plane passing through the axis of the bolt (screw shank); when doing so no account is taken of the tangential stresses on the surfaces bounding the plate. Determinations are made for the stress components and total deformation of the screw shank for cases of equal thickness (0.5 H) of the two parts being joined, by means of the method of the plane problem in the theory of elasticity. The formulas obtained were confirmed experimentally; however, in view of their complexity a much simpler expression was arrived at by using parabolic interpolation for the pliability of the screw shank L in the form of

$$L = \frac{H}{d^2 E}\left(0.5 - 0.1\frac{H}{d} + 0.007\frac{H^2}{d^2}\right)$$

where d is the diameter of the bolt (screw shank); E the modulus of elasticity of the components' material. As L is known from well-known formulas, the calculation load on the part is determinable. N. P. Beresnev

Courtesy Referativnyi Zhurnal, USSR

6120. Eickner, H. W., and Olson, W. Z., Statistical variations in the lap-joint strength of metal-bonding adhesives at elevated temperatures, For. Prod. Lab. Rep. 1880, U.S. Dept. Agric., 11 pp. + tables, Feb. 1961.

Rheology

6121. Takizawa, E. I., On the specific heat and thermal conductivity of rheological body, *Mem. Fac. Engng., Univ. Nagoya* **11**, 1/2, 59–66, Nov. 1959.

Based on Debye's and Brillouin's theories, the thermal conductivities and specific heat of liquid viscoelastic bodies and plastics are calculated. The study is based on the assumption of small relaxation coefficients for the stress-strain relation. Due to problems of translation, certain parts of the paper are not clear. For those interested in this area the paper deserves serious study. G. A. Hawkins, USA

6122. Ivyanskii, G. B., Injection of slurries into the reinforced channels of prestressed constructions (in Russian), *Prom. Str-vo* no. 2, 22–25, 1959; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13578.

The main results are given of the experimental investigations of the motion of cement slurries in a circular space, carried out in 1957–1958 in the Scientific Research Institute for the organization, mechanization and technical assistance for the building industry. Measurements were made of the capacity for motion of the slurry over a cone, of the mean velocity of motion of the slurries and of the falls in pressure. It was established that the motion of the slurries when the velocities are sufficiently small proceeds in conformity with the principles of structural (viscoplastic) liquids. For a slurry with a capacity of motion over a cone of 4–7 cm, the mean velocity of motion should not exceed 0.5 m/sec, while for a slurry when the capacity for motion is 10–11 cm the mean velocity of motion should not exceed 0.3 m/sec. At higher velocities a transition is observed from the structural to the laminar regime of motion for these slurries. It was discovered that when the slurries were in unsteady motion, which occurred when piston-actuated pumps were in use, the velocity on the transverse section of the flow varied under the action of the periodic impulses, which fact also contributes to the structural disintegration of the slurry's bonds. The influence is also noted of the forms and magnitudes of the sections on the distribution of the velocity of flow on the transverse section. As a consequence the reduction in the diameters of the reinforcing rods may result in destruction of the structural motion. Engineering details are furnished for the process of injection of slurries in constructional work. A. N. Klimentov

Courtesy Referativnyi Zhurnal, USSR

6123. Vinogradov, G. V., and Pavlov, V. P., Elastic and strength properties of soft bodies (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 2, 134–141, 1959.

Hydraulics

(See also Revs. 6034, 6121, 6226, 6230, 6231, 6236, 6237, 6241, 6251, 6398)

Book—6124. Albertson, M. L., Barton, J. R., and Simons, D. B., Fluid mechanics for engineers, Englewood Cliffs, N. J., Prentice-Hall, Inc., 1960, xiii + 567 pp. $13.

This book is an elementary and intermediate treatment of fluid mechanics and is divided into twelve chapters. The first six chapters consider the basic principles of fluid mechanics and cover topics like fluid statics, dynamics, compressibility, viscosity, turbulence and resistance. The remaining six chapters are concerned with application of the basic principles to specific problems such as flow in closed conduits, open channels and around submerged objects. Fluid measurements, hydraulic machinery, flow similitude and models are also treated.

The typography and illustrations, a total of over 250, are good.

Authors explain the fundamental principles and basic concepts in a simple way and use only elementary mathematics up to integral calculus. In the forepart of each chapter typical examples of the use of principles to be explained in that chapter are stated. Each chapter ends with a summary of the salient points of the preceding textual material. A number of graphs and tables adds to the value of the book for the practicing engineer and more than 800 problems make the book suitable as a textbook for undergraduate students. The book is generally well-written and the material is logically presented to provide steady progress from the simplest concepts to the more complex ones, which makes it suitable even for individual study. O. Soderberg, Sweden

6125. Straub, L. G., and Silberman, E., Air-water mixture flow through orifices, bends, and other fittings in a horizontal pipe, Univ. Minn., St. Anthony Falls Hydraulic Lab. Rep. 63, 58 pp., Sept. 1960.

Studies covered by a previous report [AMR **13**(1960), Rev. 5222] are extended and concluded. One-dimensional analysis is used in an attempt to improve upon purely empirical formulas for the net pressure drops in subject flows. The formulas were found to be useful for pure water, bubbly and annular flows, but not generally useful for stratified, plug and slug flows. An experimental study of the discharge of air-water mixtures into a moving water stream is appended. A. G. Fabula, USA

6126. Feringer, B. P., Krasnoyarsk hydroelectric plant on the Enisei River (in Russian), *Gidrotekh. Stroit.* **31**, 5, 2–7, May 1961.

World's largest hydroelectric plant under construction is located on Enisei River above Krasnoyarsk, central Siberia. A buttress concrete dam in a gorge will create a reservoir 235 miles long, 770 sq. miles in area. 1000,000 cfs average flow at 318-ft head will produce a 0.5 million kW power. Water power development conditions are evaluated as very favorable. Ten turbines, of 508,000 kW capacity, weighing 250 tons each, are being manufactured in Leningrad and will be transported by Arctic seaway. Inclined ship elevator with a turntable is provided for navigation purposes. Details of structures, work organization, and flood water evacuation during four years of construction are featured.

S. Kolupaila, USA

6127. Batenchuk, E. N., and Bilanov, G. F., Vilyui hydroelectric plant construction (in Russian), *Gidrotekh. Stroit.* **31**, 4, 3–7, Apr. 1961.

Power-plant construction in Yakutia, central Siberia, under unusually severe conditions, is featured. Plant is located on Vilyui River, tributary to Lena, 1000 miles above mouth. A 220-ft high rock-fill dam is built on rock over permafrost 1000 ft deep. Spillway

and evacuation tunnel are excavated in rock. Penstocks, 20 ft in diameter, carry 21,300 cfs of water under head of 170 ft, which will be increased to 223 ft in the future. Extremely difficult conditions for transportation of materials and equipment are described: air temperature in winter was as low as $-78\,^{\circ}F$, swarms of mosquitos and midges in summer made the work in swamps repulsive. The plant will supply with current a new industrial center Mirnyĭ amid desolate wilderness.

Another earth dam is built on Ireliakh River for water supply of the new city. It is provided with freezing control on a permafrost base.

S. Kolupaila, USA

6128. Dehousse, N. M., Approximative theoretical study of pressures acting on a movable weir (in French), *Bull. Centre d'Etudes, Recb. d'Essais Scient. des Construct. du Genie Civ., Liege* **10**, 389–450, 1959.

A preliminary design study of a particular type of movable weir is presented. The weir consists of a cylindrical gate with a curved vane hinged along the top which can be turned into the vertical or let down flush with the cylinder. The whole arrangement can also be lifted to operate in the manner of an undershot gate. The study is in two parts: a hydraulic study in which the discharge is related to the upstream and downstream levels using plausible coefficients for the discharge coefficients, and a hydrodynamic study in which the pressures on the gate are calculated using inviscid flow theory. The calculations are clearly laborious and approximate and take no account of flow separation. Simple laboratory tests would have given quicker and more accurate answers.

G. H. Lean, England

6129. Ovcharenko, I. Kh., Calculations for an unsubmerged spillway with lateral compression (in Russian), *Izv. Vyssb. Uchebn. Zavedenii: Energetika* no. 9, 104–111, 1958; *Ref. Zb. Mekb.* no. 11, 1959, Rev. 13610.

Results are furnished of the investigations on an unsubmerged spillway with lateral compression for the case of linked work with a trapezoidal lead-in channel of the type having opposite walls. Observations were made on the relation of the through-put capacity of the spillway to the extent of the lateral compression, the relative width of the spillway β and the coefficient of slope of the lead-in canal m. In the tests the parameters varied in the following limits: $\beta = 0.5$ to 1.0, $m = 1.0$ to 1.75, $\delta/H = 0.9$ to 5.0 where δ is the width of the threshold apron of the spillway. When working over the experimental data for the purpose of calculating the values of the coefficient of discharge use was made of the formula for an unsubmerged spillway $Q = mq^{b}\sqrt{2g}\,H_{0}^{3/2}$. Graphs were drawn, on the basis of the experimental data for the values of the coefficient of slope of the lead-in canal ($m = 1.0, 1.25, 1.50, 1.75$), to show the relation of the coefficient of discharge of the unsubmerged spillway with lateral compression to the degree of lateral compression and the relative width of the spillway.

T. N. Astaficheva

Courtesy Referativnyi Zburnal, USSR

6130. Petrov, N. A., On the through-put capacity of a spillway of practical profile in three-dimensional conditions (in Russian), (Sbornik Moskva Inzh.-Stroit. In-ta no. 24); Trudi Kafedry Gidrotekhn. Sooruzh. no. 2, 3–32, 1958; *Ref. Zb. Mekb.* no. 11, 1959, Rev. 13612.

The results are described of experiments undertaken for the determination of the through-put capacity of unsubmerged non-vacuum spillways of practical profile with lateral compression. The coefficient of lateral compression is a function of the flow in plane and of the relative width of the spillway's opening. The experimental data are compared with the calculations (using the method of fragments).

A. R. Berezinskii

Courtesy Referativnyi Zburnal, USSR

6131. Gints, A. S., The discharge coefficient of a spillway (in Russian), *Trudi Omskogo S.-Kb. In-ta* **26**, 153–161, 1958; *Ref. Zb. Mekb.* no. 11, 1959, Rev. 13615.

Data of investigations obtained in laboratory conditions for the study of the relation of the discharge coefficient of a polygonal spillway to the slope of the spillway's face are given. The slopes i of the face of the spillways changed from 0.05 to 1.00. Models were constructed with a pointed inlet edge. The investigations were carried out without any side compression and without submergence of the spillway, access to air being ensured under the overflowing current. In the experiments readings were taken of the crest of the spillway level, of the level of the water at the threshold and of the discharge. The coefficient of discharge was determined from the experimental data by the formula

$$Q = mb\sqrt{2g}\,H_{0}^{3/2}$$

Following an analysis of the experimental data recommendations are put forward for the determination of the coefficient of discharge of an unsubmerged polygonal spillway with a pointed entry edge without lateral compression at slopes for the spillway's faces varying from 0.05 to 0.30.

$$m = 0.3245 + 0.2683\,i$$

or

$$m = m^{*} + 0.3353\,i - 0.2769\,i^{2}$$

where m^{*} is the coefficient of discharge of the unsubmerged spillway with a wide threshold at assigned dimensions of the profile being studied (with $i = 0$).

T. N. Astaficheva

Courtesy Referativnyi Zburnal, USSR

6132. Chavtoraev, A. I., Hydraulic calculations of oblique and side spillways (in Russian), *Naucbn. Zap. Mosk. In-ta Inzb. Vodn. Kb-va* **20**, 132–143, 1958; *Ref. Zb. Mekb.* no. 11, 1959, Rev. 13616.

A short critical review is given of the existing formulas for the determination of discharge through a side spillway. Author obtains a theoretical relationship for the determination of the discharge from oblique and lateral spillways (with a depth of the flow in the region of the lay-out of the spillway greater than the critical); this he does by adopting the curve for the free surface in the canal in the limits of the lateral spillway as having a parabolic form and by making a number of assumptions. In addition, empirical relations are proposed for the determination of (1) the width of the entrapment of the surface currents into the spillway; (2) the angle between the direction of the velocity and the crest of the spillway; (3) the discharge when the water is being drawn off laterally (that is from a submerged lateral spillway).

T. N. Astaficheva

Courtesy Referativnyi Zburnal, USSR

6133. Rajaratnam, N., Direct solution for diameter of pipe in rough turbulent flow (in French and English), *Houille Blanche* **15**, 6, 714–719, Nov. 1960.

To determine the diameter of a pipe with fully developed turbulent flow when discharge, loss of energy, fluid characteristics and roughness of pipe are known, author approximates a slightly curved line deduced from the Prandtl-Kármán equation with a straight line on a log-log plot, thus having a formula in potential form. In fact, the resulting formula is nearly identical with Manning's formula, with the diameter in the power 0.65, according to reviewer's calculation.

The accuracy and the range in relative roughness of the approximation is not discussed. Reviewer finds that the paper is an example of the problem dealt with by Diskin (see following review). Thus, the flow in the numerical example chosen by author for illustrating the use of the method proves to be in the transition (smooth) zone and not in the rough turbulent zone.

To engineers who prefer potential formulas instead of diagrams, as Moody's, for flow calculations, reviewer recommends a study of Bretting's work, referred to in the following review.

H. T. Kristensen, Sweden

6134. Diskin, M. H., The limits of applicability of the Hazen-Williams formula (in English), *Houille Blanche* **15,** 6, 720–723, Nov. 1960.

Author states that Hazen-Williams' formula for pipe flow computations is often used in engineering practice beyond the limits within which the application will give reliable results. Author determines the limits by using Darcy-Weisbach's equation to bring the Hazen-Williams' formula in suitable form and superimposing the formula on Moody's diagram. The comparison with the lines of the diagram gives the interval in friction coefficient, suitable for use with the formula, and the corresponding intervals in Reynolds number, within which the formula is applicable for flow computations. The results are given only for water at ordinary temperature.

Reviewer points out that the problem dealt with by author is characteristic for most empirical formulae for flow computations used in engineering practice, for instance Manning's formula. In I.A.H.R. Bull. 2 meeting, 399–415, 1948, Bretting reports his investigations of formulae for flow in pipes and open channels. He presents a set of flow formulae on potential form covering engineering practice for all fluids and conduits, and he also gives the limits for the formulae. One of Bretting's three formulae for fully developed turbulence is identical with Manning's formulae, and the two formulae for the transition (smooth) flow zone are nearly identical with the Blasius' formula and the Hazen-Williams' formula. Experience connected with these well known formulae and many others has been used for calculation of friction coefficients, see A. E. Bretting, "Hydraulik," Copenhagen 1960, 154 ff (in Danish).

H. T. Kristensen, Sweden

6135. Gurevich, M. I., and Pykhteev, G. N., Approximate solution of the problem of the flow of a heavy ideal incompressible fluid from under a sluice gate (in Russian), *Zh. Prikl. Mekh. Tekh. Fiz.* **2,** 3–14, 1960.

The results of extensive experimental studies to determine the pressure losses for turbulent flow in smooth pipe bends of circular cross section are presented. To make the data usable in practical design problems, the results are discussed in relation to those found by previous investigators, and empirical formulas for the bend-loss coefficient are given. The general correlation of the test data appears to be as good as present test information will permit.

From authors' summary

6136. Bleines, W., Calculation of nonuniformly flowing discharge in open water channels (in German), *Bauingenieur* **36,** 5, 169–174, May 1961.

Author considers the nonuniform flow in open channels and develops a method for taking into account the individual losses. The method employed is exact. However, reviewer believes that for practical purposes method with assumption of difference in water levels (Böss-method) would also give good results.

P. Franke, Germany

6137. Ovcharev, E. E., Hydraulic resistance in the even motion of a liquid in open channels (in Russian), *Naucbn. Zap. Mosk. In-ta Inzh. Vodn. Kb-va* **20,** 180–197, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13594.

Experiments were carried out in the hydraulics laboratory of the Moscow Institute of water economy engineers on the resistance of open channels to the motion of water. Investigations were carried out with six artificially induced degrees of roughness produced by means of river sand, fraction by fraction or in combinations of fractions two or more at a time. Each type of roughness was investigated with 7–10 different slopes of the bottom of the trough, varying from 0.000485 to 0.00590. The experiments were carried out with values for the Reynolds numbers R from 4000 to 60,000. The experiments showed that the curves $\lambda = f(R)$ for all the degrees of roughness tested are characterized by the presence of the so-called Nikuradze "spoon-shaped curve" (decrease of the coefficient of hydraulic friction with decrease in the Reynolds number). The conclusion of the author to the effect that a similar phenomenon would manifest itself at degrees of roughness met with in engineering practice is, however, refuted by the results of other experiments [E. Marchi, *Ric. Scient.* **26,** 8, 2448–2473, 1956; V. I. Kalitsun, *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 3, 171–172, 1958] which confirm the monotony of the resistance curve, which also results from the abstractor's formula [*Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 85–94, 1956]. On the basis of the experiments carried out by him the author recommends that the value of the exponent of the degree y in Pavlovskii's formula for Chezy's coefficient, when making calculations for small channels (r less than 0.10 m) should be determined from the relation $y = 1.7\sqrt{n}$. It is also shown that the coefficient in the case of the logarithm in I. I. Agrostin's formula depends on the roughness and that with hydraulic radii less than 0.3 m it can also be found by means of the formula

$$A = 54 - 240\sqrt{n}$$

where n is the coefficient of roughness in Pavlovskii's formula.

A. D. Al'tshul'

Courtesy Referativnyi Zhurnal, USSR

6138. Holsters, H., Stability and convergence in the step by step numerical calculation of unsteady flow in rivers (in French), *Bull. du Centre d'Etudes, Rech. d'Essais Scient. des Construct. du Genie Civ., Liege* **10,** 451–482, 1959.

In general because of the complexity of the initial and boundary conditions it is necessary to solve the "one-dimensional" equations of unsteady flow for rivers and estuaries by a numerical method. For such a method to be of practical value it must be convergent, i.e. if the finite difference steps Δx, Δt tend toward zero the solution should tend toward the exact solution of the equations. In addition the procedure must be stable, so that the solution is independent of small errors in calculation. By making certain approximations the equations can be linearized with constant coefficients and the condition for stability is then

$$\frac{\Delta x}{\Delta t} \geq C$$

in which C is the velocity of propagation of infinitesimal waves. Convergence depends on the nature of the discontinuities present in the initial conditions; if there are no discontinuities of zero order and only a finite number of discontinuities of the first order the solution will be reasonably exact for sufficiently small steps.

G. H. Lean, England

6139. Ivanov, A. N., Cavitating flow around airfoils (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 6, 117–120, Nov./Dec. 1960.

Tulmin's and Geurst's studies of cavitating flow considered two-dimensional cases with limiting assumptions of weightless fluid,

cavitating area bordered by the flow streamlines, zero thickness airfoils, small angles, etc. Present work is extended to airfoils of arbitrary shapes with rounded leading edges. Method of analysis is based on representing cavitated area by a system of sources and use of conformal transformation to determine aerodynamic coefficients of cavitated airfoils. W. Z. Stepniewski, USA

6140. Laing, R. A., and Rorschach, H. E., Jr., Hydrodynamic drag on spheres moving in liquid helium, *Physics of Fluids* **4,** 5, 564–571, May 1961.

The drag coefficient of spheres falling in liquid helium I and II and in some ordinary fluids for Reynolds numbers between 10^4 and 3×10^5 has been measured. The values of the drag coefficient and the size of the wall corrections for helium I agree with the helium II results and with the results obtained for ordinary fluids. The drag crisis in liquid helium is postponed, but this can be explained by the small value of its kinematic viscosity and the dynamics of boundary-layer formation. This agreement suggests that helium I and helium II can be described at high Reynolds numbers by a single velocity field satisfying a Navier-Stokes equation.

From authors' summary

6141. Rao, N. S. G., Seetharamaiah, K., and Swamy, N. V. C., Dissipation of energy of a circular jet submerged in water (in French and English), *Houille Blanche* **15,** 6, 704–713, Nov. 1960.

This paper deals with the study of the dissipation of energy of a high-velocity jet flowing into a standing mass of water. At the instant when the jet enters the standing pool of water, the jet possesses the maximum energy which is gradually dissipated along its passage in the surrounding medium. This paper reports some studies undertaken with a view of studying the mechanism by which the energy of the jet decreases to a minimum. A hypothesis for the existence of a critical region where the energy of the jet is reduced to a minimum has been put forward and found to hold experimentally. Studies are also reported regarding the magnitudes of the bed velocities under various conditions of flow.

From authors' summary

Incompressible Flow

(See also Revs. 5867, 6179, 6209, 6217, 6220, 6226, 6242, 6243, 6253, 6287, 6339, 6342, 6429)

Book—6142. Brenkert, K., Jr., Elementary theoretical fluid mechanics, New York, John Wiley & Sons, Inc., 1960, xi + 348 pp. $7.50.

A beginning student can easily lose sight of basic ideas if he becomes engrossed too soon in the details of application or in the techniques of problem solution. Therefore the author has developed the fundamentals with a minimum of attention to practical applications. However he has introduced some discussion of applications that serve to illustrate and augment the student's grasp of principles.

The book contents: (1) Introduction, definitions, and concepts. (2) Fluid statics. (3) Conservation of matter and Euler equation. (4) Momentum and angular momentum. (5) Conservation of energy. (6) Friction. (7) Dimensional analysis and model study. (8) Potential flow. A. Betz, Germany

6143. Rudiger, D., A variational principle for hydrodynamics (in German), *ZAMM* **41,** 1/2, 66–72, Jan./Feb. 1961.

A variational principle is established which is equivalent to the third boundary-value problem of the linearized Navier-Stokes equations for steady motion. The only condition to be fulfilled is that the adjacent velocity fields satisfy the continuity equation.

From author's summary by S. D. Nigam, India

6144. Bohlin, T., On the drag on a rigid sphere moving in a viscous liquid inside a cylindrical tube (in English), Kungl. Tekn. Hogskol. Handl. no. 155, 63 pp., 1960.

The influence of the walls of a cylindrical tube on the drag of a small rigid sphere moving with constant velocity μ_0 in a viscous liquid is considered. The Navier-Stokes equations (quadratic terms being neglected) are solved in cylindrical and spherical coordinates, and general solutions are set up containing unknown weighting functions. By applying the boundary conditions on the surface of the sphere to the solution in spherical coordinates, and the corresponding conditions on the cylinder wall to the solution in cylindrical coordinates, conditions are imposed upon the weighting functions in spherical and cylindrical coordinates respectively. These conditions, together with the relations obtained by equating the two solutions, determine the stream completely. To use these relations for obtaining a solution, an iterative method is used, starting from the Stokes solution for an infinite medium. Thus recurrence formulas are obtained, determining an arbitrarily close approximation to the actual stream. The drag is computed as a power series expansion in terms of the ratio of the sphere radius a to the cylinder radius b. The following drag formula is obtained:

$$D = 6\pi\mu a u_0 / f\left(\frac{a}{b}\right),$$

where

$$f(\lambda) = 1 - 2.10443\lambda + 2.08877\lambda^3 - 0.94813\lambda^5 - 1.372\lambda^6 + 3.87\lambda^8 - 4.19\lambda^{10}$$

This formula holds on the assumption that $\frac{a}{b}(Re)^2$ is negligible as compared with unity, where $Re = \rho u_0 b/2\mu$. Reviewer would like to mention that although this paper constitutes a new contribution to the problem of effective computation of the drag, the more general case of an eccentric sphere moving in a cylinder was previously solved by H. Brenner and J. Happel, [*J. Fluid Mech.* **4,** 195–213, 1958]. D. Gh. Ionescu, Roumania

6145. Wolska-Bochenek, J., Boundary-value problem for an unbounded domain in the theory of unsteady motion of a viscous liquid (in French), *Arch. Rational Mech. Anal.* **7,** 3, 196–211, Mar. 1961.

Proof is presented of existence of solution to the equations for plane flow continuing a given initial motion in the region outside of a set of smooth closed curves. Method is a clear illustration of use of Schauder fixed-point theorem. C. M. Ablow, USA

6146. Golubev, V. V., Influence of viscosity on flow around the wing (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 6, 3–14, Nov./Dec. 1960.

This paper, edited from works left by the late author (1884–1954), considers role of viscosity in (a) rolling of vortex sheet into a pair of trailing vortices and (b) leading edge separation (stall). Theories based on ideal fluid concept cannot explain rolling of the individual vortex filaments of the vortex sheet into two vortex stresses and could only indicate rotation of the two halves of the sheet as a whole. However, due to viscosity, flow in the wake becomes turbulent and filaments of fluid can be treated at any given moment as rigid bodies submerged in flow field created by particular vortices. This would result in pressure differential on those quasi-rigid filaments pushing them forward as cores of vortices, finally leading to formation of trailing vortices located at

0.817 semispan. Influence of viscosity on angle of attack at which leading edge separation occurs is considered for the case of a flat plate, and formulas for stalling angle are developed.

W. Z. Stepniewski, USA

6147. Hocking, L. M., The stability of a rigidly rotating column of liquid, *Mathematika* **7,** 13, 1-9, June 1960.

The stability of a rigidly rotating column of liquid under axisymmetric and plane disturbances is considered. The rotation of the column has an unstabilizing influence. So, for axisymmetric disturbances the inviscid column will be unstable if the wavelength of the disturbance exceeds the circumference, while for smaller wavelengths the surface tension is sufficiently large to overcome the effect of the rotation. It might be supposed that the viscosity would increase the range of stability, but this is not found to be true, as a high viscosity leaves the stability criterion unaltered. For plane disturbances, it is found that for high and low viscosities, the column is stable for disturbances of all wave numbers, if the surface tension $T > \rho\Omega^2 a^3/3$, where ρ is the density of the liquid, Ω is the angular velocity, and a is the radius of the column.

D. Gh. Ionescu, Roumania

6148. Khamrui, S. R., On the oscillation of a circular cylinder in a viscous liquid contained in a co-axial circular cylinder, *Bull. Calcutta Math. Soc.* **52,** 1, 45-50, Mar. 1960.

The liquid is enclosed between two infinite coaxial circular cylinders. The liquid motion due to axial oscillations of the inner cylinder in the presence of radial suction at the inner and an equal radial injection at the outer cylinder is studied.

S. D. Nigam, India

6149. Emmons, H. W., Chang, C. T., and Watson, B. C., Taylor instability of finite surface waves, *J. Fluid Mech.* **7,** 2, 177-193, Feb. 1960.

A brief review of various studies made during past decade on the topic of interfacial instability of accelerated fluids is first presented by authors. Such previous investigations comprise first- and second-order theories, which authors extend. Their analysis involves determination of velocity potential in a semi-infinite liquid superimposed on a second semi-infinite fluid of negligible density. Boundary conditions include effect of surface tension; an initial harmonic surface disturbance is selected. Expansion-type solutions for surface disturbance and velocity potential are assumed. A "cut-off wave number," reflecting surface tension and gravity forces, is defined. A dimensionless cut-off wave number k (ratio of disturbance wave number to dimensional cut-off wave number) is the parameter which characterizes the physical problem. Authors' analysis results in reiteration of previously obtained first- and second-order theories and leads to more complicated third-order expressions.

Several experiments were conducted using methanol or carbon tetrachloride and air. Data were obtained from photographic record of glass frame (12 in. × 5 in. × 1 in.) accelerated downward by stretched rubber tubes. Initial surface disturbance was created by oscillating paddle. Below the cut-off wave number ($k < 1$), experimental results agree well with theory; discrepancies seem due to difficulty in initial amplitude determination.

Study is also made of interfacial behavior during later stages of wave growth, of spike acceleration and of bubble formation and velocity. Edge effects in rectangular frame led to study of acceleration of liquid sheets at walls. Observed spike accelerations were about half the free-fall rate (and hence in disagreement with previous theories); leading-edge accelerations of liquid sheets were about 0.6 to 0.7 the free-fall value. Throughout the study, surface tension was given quantitative consideration though viscosity effects were neglected.

R. B. Banks, Thailand

6150. Feind, K., Falling liquid films with counter current air flow in vertical tubes (in German), *Forsch. Geb. Ing-wes.* (B) **26,** 35 pp., 1960.

Paper is primarily an empirical correlation of factors defining flow of liquid film on inside of tube surface and counter current air flow in center. From dimensional analysis five groups are obtained which characterize the flow. Description is given of a series of experiments with air and glycol-water mixtures in which ranges of all variables were encountered. From the results a single parameter is defined which consists of an exponential combination of the dimensionless groupings. Friction factor of gas flow is then shown to be a simple function of this parameter. A similar expression is obtained which defines conditions for flooding of the liquid film. Experimental results from other sources are shown to be in close agreement with this formulation. Some basic theory for laminar flow is given to indicate the condition at the air-liquid interface. Experimental studies are, however, extended to turbulent flow in both film and gas.

Reviewer finds paper a clear, concise presentation of a complex problem. It should be of particular interest to design engineers.

W. D. Baines, Canada

6151. Friedlander, S. K., A note on transport of spheres in Stokes flow, *AIChE J.* **7,** 2, 347-348, June 1961.

The influence of the walls of an infinitely long cylindrical tube on the drag of a small rigid sphere moving slowly in a viscous liquid is considered. The linear parts of the Navier-Stokes equations are solved in cylindrical and spherical coordinates and general solution is set up containing unknown weighting functions. By the boundary conditions on the surface of the sphere or the cylinder, conditions are imposed upon the weighting functions; adding the relations obtained by equating the two solutions, the stream is completely determined. The drag is expressed as a power series expansion in the ratio of sphere radius to cylinder radius. If a Poiseuille stream is added, the drag is modified accordingly.

R. Nardini, Italy

6152. Cohen, M. J., Two-dimensional gas jets, *ASME Trans.* **82** E (*J. Appl. Mech.*), 4, 603-608, Dec. 1960.

By making simplifying assumptions which are shown to be justified for two classical cases, author presents a method for solving certain subsonic aerodynamic design problems where flow boundaries are required to have prescribed dynamic characteristics.

Use is made of log-modified hodograph plane with approximations, and results for two-dimensional jet agree within 2% to Chaplygin's exact solution. Method will be useful where conformal techniques are valid.

R. H. Eustis, USA

Compressible Flow (Continuum and Noncontinuum Flow)

(See also Revs. 5867, 6184, 6188, 6195, 6202, 6203, 6204, 6205, 6206, 6210, 6214, 6240, 6254, 6255, 6260, 6301, 6336, 6373, 6378)

6153. Cook, R., An analysis of the flow over two 45-deg sweptback wings at high subsonic speeds, and comparison with theory, Aero. Res. Counc. Lond. Rep. Mem. 3194, 40 pp., 1961.

This paper presents a comparison of pressure distributions obtained from theory and from wind-tunnel tests on two sweptback wings at various incidences and Mach numbers. The first wing, having NACA 65A004 sections, had a taper ratio 0.2, an aspect ratio of 3, and had its quarter-chord line swept back through 45 deg. The second wing had RAE 102 sections, a taper ratio of 1/3,

an aspect ratio of $2\sqrt{2}$, and had its semichord line swept back through 45 deg. The experimental flow conditions and patterns are briefly discussed here insofar as they are relevant to the comparisons. From author's summary

6154. Kussner, H. G., Research on the oscillating elliptic lifting surface in subsonic flow, AFOSR TR 60-71, 75 pp., June 1960.

6155. Falkovich, S. V., Plane transonic gas flows with singularities on the sonic line, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **25,** 2, 218-228, 1961. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

The full equation of Chaplygin for the stream function ψ of the plane potential isentropic transonic flow is studied with the objective of obtaining solutions with a singularity on the sonic line. Guided by the character of the corresponding solutions of the Tricomi equation, the variables $\rho = (\theta^2 + 4\eta^{3/4})^{1/2}$ and $t = \theta/\rho$, (where θ, η are the modified hodograph variables) are selected and ψ expressed as

$$\sum_{m=0}^{\infty} \rho^{\lambda+2m/3} f_m(t).$$

The important three leading terms are determined explicitly in terms of combinations of hypergeometric functions. A very detailed application is made to the problem of sonic flow around a diamond airfoil. In particular, it is shown how the normal series based on Chaplygin's hypergeometric functions is selected to exhibit the required singular behavior and to satisfy the proper boundary conditions. Finally, a procedure for obtaining asymmetric solutions for the sonic flow around a flat plate at an angle of attack is outlined. M. V. Morkovin, USA

6156. Gontier, G., Procedure for the experimental determination of the transonic region in a flow of mixed type (in French), Publ. Scient. Tech. Min. Air, France no. 367, 236 pp., 1960.

The first half of the monograph presents detailed calculations of the flow through the minimum section of a symmetrical nozzle. The analysis parallels that of R. Sauer (see NACA TM 1147); a polynomial solution for the transonic flow is extended into the supersonic region by method of characteristics. The second half of the monograph describes pressure measurements made close to the throat of a two-dimensional nozzle. Static pressures were measured on a long slender tube extending through the nozzle parallel to the center line. A small conical reduction in the tube diameter was used to generate a weak expansion wave disturbance. Pressure surveys determine the extent of the region of supersonic flow from which disturbances could be propagated upstream into the subsonic flow. Upstream propagation through the turbulent boundary layer on the survey tube is analyzed.

G. E. Nitzberg, USA

6157. Whitcomb, C. F., and Norton, H. T., Jr., Transonic investigation of aerodynamic characteristics of a swept-wing fighter-airplane model with leading-edge droop in combination with outboard chord-extensions and notches, NASA TN D-834, 30 pp., May 1961.

The investigation of the 45° swept-wing model was conducted to determine the effects of wing leading-edge droop in combination with outboard chord-extensions and notches on the longitudinal stability and performance characteristics. Comparison with results for a configuration with leading-edge slats is included. These devices provided only slight improvement of the longitudinal stability characteristics but substantially decreased the airplane drag coefficients at moderate and high lifting conditions.

From authors' summary

6158. Runckel, J. F., and Hieser, G., Normal-force and hinge-moment characteristics at transonic speeds of flap-type ailerons at three spanwise locations on a 4-percent-thick sweptback-wing-body model and pressure-distribution measurements on an inboard aileron, NASA TN D-842, 55 pp., May 1961.

Aileron normal-force and hinge-moment characteristics have been obtained by strain-gage and pressure-distribution measurements for flap-type ailerons located at inboard, midspan, and outboard positions on a 45° sweptback-wing-body combination at Mach numbers from 0.80 to 1.03 and at angles of attack up to about 27°, with control deflections between approximately −15° and 15°.

From authors' summary

6159. Serbin, H., Flow induced by a cavity in a supersonic stream, *J. Aerospace Sci.* **28,** 3, 247-248 (Readers' Forum), Mar. 1961.

Standard source-potential theory of linearized aerodynamics is used to calculate the disturbance to a supersonic stream caused by a rectangular pit in a plane surface, such as an open bomb bay in the underside of an aircraft fuselage.

The "slope" of the disturbing surface is represented as a Dirac delta-function at the leading edge of the pit. The simple formulas so obtained for the perturbation potential enable the author to construct a qualitative picture of flow over and within the bomb bay. A. H. Armstrong, England

6160. Schaaf, S. A., Moulic, E. S., Chahine, M. T., and Maslach, G. J., Aerodynamic characteristics of wedges in low density supersonic flow, *ARS J.* **31,** 2, 194-200, Feb. 1961.

Correlation is made between theory and experiment on aerodynamic forces and moment of two-dimensional wedges (5° and 30° half angles) at $M = 4$ and 6 for Reynolds numbers of 1500 to 8900 (based presumably upon free-stream density and temperature and length of wedge). Theory involves a weak interaction consideration with the inviscid pressures calculated by Newtonian method. Satisfactory agreement is obtained. Where interaction plays an important role, it is pointed out that simulation of the boundary layer, through the correct stagnation temperature, is important. H. Yoshihara, USA

6161. Komarovskii, L. V., On spatial gas flows with degenerate hodographs, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **24,** 3, 717-723, 1960. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Writer investigates isentropic flows of a gas whose hodographs degenerate into self-similar manifolds or into a manifold of degree smaller by one. In particular, he considers double waves without the assumption that the flow is potential. The starting point is the equations of motion and continuity in which the pressure and the density are expressed in terms of the velocity of sound. Writer considers the case where the hodograph velocity degenerates into a two-dimensional surface, which is a plane. Equations of motion and continuity are transformed into a system of nonlinear partial differential equations which is more compact and uniform than the original one. Writer investigates the matrix which consists of the coefficients of this system and, depending upon the rank of this matrix, various cases are obtained. The case r (rank) = 4 leads to u_i (velocity components) = const. The case $r = 2$ leads to two equations for the hodograph surface. The case $r = 3$ leads to a two-parameter family of two-dimensional manifolds intersecting along a common straight line. The case of $r = 1$ leads to a linear inhomogeneous equation for u_i. As a special case, writer investigates the steady flow with $r = 2$. It follows that only supersonic flows are possible in this case. The resultant equations for the hodograph surface are two quasi-linear equations of the second order. M. Z. v. Krzywoblocki, USA

6162. Rosciszewski, J., Hypersonic flow around bodies of revolution, *J. Aerospace Sci.* **28,** 2, 168–170 (Readers' Forum), Feb. 1961.

An approximate method for calculating the shock wave shape and the pressure distribution for nearly conical bodies is presented. The approximation is appropriate only for hypersonic flow, but allows computations to be made without the necessity of employing the method of characteristics. A sample calculation shows good agreement with a solution found by the method of characteristics.

T. C. Adamson, Jr., USA

6163. Boyd, E. A., Busemann correction to the characteristics of the two-dimensional hypersonic sail, Coll. Aero. Cranfield, Rep. 140, 7 pp. + figs., Nov. 1960.

It appears that the concept of using flexible membranes in tension as aerodynamic lifting surfaces has been accepted. See, for example, NASA TN D-443, Rogalio et al. A number of static and dynamic aeroelastic problems of interest arise as a result of the use of such structures. The two-dimensional static aeroelastic problem at hypersonic speeds is discussed here. The corresponding supersonic problem appears in another report by the same author (see review below).

The shape, pressure distribution, force and moment coefficients for the title problem are found for the Newton-Busemann pressure law. Results are compared with those of Daskin and Feldman [AMR **11**(1958), Rev. 2713] who used the modified Newtonian pressure law. As noted by Hayes [AMR **13**(1960), Rev. 1288] the sail shape for the corrected pressure law is parabolic. The sail under the corrected pressure law is more effective than the uncorrected one; i.e., for a given chord and tension it has higher aerodynamic forces.

W. Daskin, USA

6164. Boyd, E. A., The characteristics of a two-dimensional supersonic sail, Coll. Aero. Cranfield, Rep. 143, 6 pp. + figs., Dec. 1960.

Form of analysis yielding shape and aerodynamic coefficients, as in previous paper (see above review) follows that of Daskin and Feldman. The results are limited to deflections (compressions) for which the oblique shock wave remains attached and the boundary layer unseparated. The Busemann second-order supersonic pressure law is used; the corresponding universal sail shape is a Sici Spiral. Estimates of the required tensile stresses indicate that the sail will have to be made of a flexible metallic material, for example, woven wire.

W. Daskin, USA

6165. Baradell, D. L., and Bertram, M. H., The blunt plate in hypersonic flow, NASA TN D-408, 49 pp., Oct. 1960.

Authors compare various methods for calculating inviscid hypersonic flow parameters on blunt two-dimensional bodies for several values of ratio of specific heats. First method is sonic-wedge characteristics method in which blunt leading edge is replaced by wedge whose inclination is such that flow between shock and wedge is sonic. Thus, flow in this region is known, and flow downstream of shoulder is determined by method of characteristics. Second method is blast wave theory which is compared for power law bodies only. Third method is tangent wedge approximation. Blunt bodies at angle of attack are considered. In addition to these problems authors consider effects of free-stream conical-flow gradient using first method. This problem finds application in reducing hypersonic wind-tunnel test data, much of which is obtained in conical nozzles.

T. R. Goodman, USA

6166. Sychev, V. V., Three-dimensional hypersonic gas flow past slender bodies at high angles of attack, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **24,** 2, 296–306, 1960. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Writer investigates three-dimensional hypersonic flow past bodies whose transverse dimensions are much smaller than their length. Making use of the smallness of a parameter characterizing the relative thickness of the body, it is possible to express the problem of the flow past such a body approximately in a form that generalizes the similitude of hypersonic small-disturbance flow to the case of arbitrary angle of attack. The writer introduces dimensionless cylindrical polar coordinates and the system of equations of motion, continuity and of the conservation of entropy in these coordinates. Next, the writer puts down the equation of the shock wave surface in a general form and the equations of conservation of mass, momentum and energy relating the quantities on both sides of the shock wave. To simplify these equations, the writer takes advantage of the smallness of the parameter characterizing the relative thickness of the body, i.e., all the equations of motion, boundary conditions on the surface of the body and on the shock wave surface are linearized. The writer introduces two similitude parameters (one proportional to Mach number, another to the relative thickness) and all the dimensionless velocity—and pressure—functions are equal at the corresponding points of the field if the two similarity parameters have the same values for two cases. Using the resulting similarity rule, the writer writes the formula for the pressure coefficient on the surface of the body, for the normal force coefficient, axial coefficient and the longitudinal moment coefficient. The next problems attacked by the author are the aerodynamic characteristics of slender bodies at high angles of attack; here there remains only single similarity parameter which becomes small for high angles of attack. This is used as a parameter to linearize the equations of motion and boundary conditions. Some remarks on taking into account real gas properties close the paper.

M. Z. v. Krzywoblocki, USA

6167. Sychev, V. V., On the theory of hypersonic gas flow with a power-law shock wave, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **24,** 3, 756–764, 1960. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Characteristic features of entropy layer generated by a blunt nose in two-dimensional hypersonic flow are discussed on the basis of an inverse method in the case of power law shock waves. Author proposes to use similarity solution for obtaining $p(x, \psi)$ (p pressure, ψ stream-function); then, exact equations are used to reproduce physical coordinates. The explosion solution in axisymmetric flow is thus completely worked out, giving a body of considerable thickness (about half of the whole shock-layer thickness), in comparison to the vanishing thickness given by the true explosion solution.

J. P. Guiraud, France

6168. Zakkay, V., Preliminary experimental investigation of the flow about a blunt body with flow-separation spikes at $M_\infty = 7.9$, AFOSR 219 (Polyt. Inst. Brooklyn, Dept. Aerospace Engng. Appl. Mech., PIBAL Rep. 631), 15 pp., Feb. 1961.

6169. Ladyzhenskii, M. D., Hypersonic streaming of thin blunt bodies (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 150–151, Jan./Feb. 1961.

6170. Stakhanov, I. P., and Stupochenko, E. V., The structure of Mach lines in relaxing media, *Soviet Phys.-Doklady* **5,** 5, 964–968, Mar./Apr. 1961. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **134,** 5, 1044–1047, Oct. 1960 by Amer. Inst. Phys., Inc., New York, N. Y.)

In order to study the characteristics of the equations of relaxation hydrodynamics [AMR **14**(1961), Rev. 6171], flow past a thin wedge at zero angle of attack is studied. Its solution is obtained in a form of contour integral, and compared with that of usual hydrodynamic equations. The structure of the Mach line and the

propagation of small disturbances in a relaxing media are investigated in detail. M. Kawaguti, Japan

6171. Stupochenko, E. V., and Stakhanov, I. P., The equations of relaxation hydrodynamics, *Soviet Phys.–Doklady* **5,** 5, 957–960, Mar./Apr. 1961. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **134,** 4, 782–785, Oct. 1960 by Amer. Inst. Phys., Inc., New York, N. Y.)

There are some differences between the usual hydrodynamical equations and the equations of "relaxation hydrodynamics," even when τ, the time for establishing local thermodynamical equilibrium, is sufficiently small. To explain these discrepancies, a formal expansion of the solution of the equations of relaxation hydrodynamics in a power series of τ is obtained.

M. Kawaguti, Japan

6172. Werner, J. E., Unsteady interaction of a shock wave with a cellular vortex field, *J. Fluid Mech.* **10,** 2, 195–208, Mar. 1961.

Author treats the passage of a semi-infinite, solenoidal cellular flow through a normal shock wave. For long times after the passage of the interface, the problem essentially reduces to H. S. Ribner's [NACA Tech. Note 2864, 1953; AMR **6**(1953), Rev. 3134] and the new result here is the transient part of the solution. Due to the strong nonlinear interaction with the shock wave, all three fluctuation modes (sound waves and entropy fluctuations as well as the modified vorticity pattern) are present behind the shock wave; furthermore, the portion of the shock wave also fluctuates.

The analysis is also extended to treat the case of the passage of a single vortex row through the normal shock.

L. S. G. Kovasznay, USA

6173. Ryhming, I. L., The supersonic boom of a projectile related to drag and volume, *J. Aerospace Sci.* **28,** 2, 113–118, 157, Feb. 1961.

Far-flow field (Whitham) results are employed to find geometries yielding maximum and minimum shock pressure jumps under drag and fineness ratio constraints. It is shown that minimum boom corresponds to minimum drag and that boom intensities vary only 10% upon fixing length and fineness ratio.

J. R. Baron, USA

6174. Blythe, P. A., Comparison of exact and approximate methods for analysing vibrational relaxation regions, *J. Fluid Mech.* **10,** 1, 33–47, Feb. 1961.

The validity of various solutions for the vibrational relaxation region in shock waves, and of the assumptions on which they are based, has been assessed by comparison with an exact solution obtained by numerical integration of the relaxation equation, and also by use of the Rayleigh-line equations. Estimates of errors in the values of the relaxation frequency, determined by means of these solutions, are given.

From author's summary by A. E. Seigel, USA

6175. Johannesen, N. H., Analysis of vibrational relaxation regions by means of the Rayleigh-line method, *J. Fluid Mech.* **10,** 1, 25–32, Feb. 1961.

Author analyzes vibration relaxation region behind a shock by expressing the applicable equations in the form of those for an ideal gas with heat transfer. These equations, which are exactly those which describe the Rayleigh line, may then be applied at each point in the relaxation region; in particular, from experimental density distributions the local value of relaxation frequency may be calculated at each point in the relaxation zone.

A. E. Seigel, USA

6176. Andersen, W. H., and Hornig, D. F., Structure of weak shock fronts in argon-helium mixtures, *Physics of Fluids* **4,** 5, 650–651 (Letters to the Editor), May 1961.

6177. Szaniawski, A., Certain dynamical problems of a perfect gas with decomposable molecules (in French), *Arch. Mech. Stos.* **12,** 4, 483–496, 1960.

Author considers a new model for a dissociating and/or ionizing gas, with the purpose of reducing calculational complexity. According to this model, dissociation and ionization take place in a discontinuous fashion, akin to change in phase. Thus $p = \varphi(T)$ is a curve separating completely dissociated (or ionized) and completely undissociated (or un-ionized) regions. Several example problems are solved using this model. The speed of sound of dissociating nitrogen is calculated and reasonable agreement obtained with more exact calculations. Calculations are also carried out for the relations between p and ρ across shocks in air, including effects of dissociation for both oxygen and nitrogen.

A. L. Loeffler, Jr., USA

6178. Lipps, H., On the calculation of axisymmetric nozzle flows (in German), *ZAMM* **40,** 10/11, 507–510, Oct./Nov. 1960.

Power series solutions of the form

$$\phi(x, y) = \Sigma\, c_{mn}\, x^m\, y^n$$

have been used with success in the calculations of transonic and supersonic flows in axisymmetric nozzles.

In this paper a general proof of convergence is deduced from the corresponding theorem for plane two-dimensional flow. It is shown that each coefficient c_{mn} in the series solution for an axisymmetric flow is less than the corresponding coefficient of the series solution for a plane flow. E. P. Sutton, England

6179. Hunt, J. N., Taylor instability in a thin fluid layer, *Appl. Scient. Res. (A)* **10,** 1, 45–58, 1961.

Paper discusses instability of thin inviscid fluid layer interposed between two semi-infinite media when an acceleration is imposed normal to the layer. External media are each of constant density. Intermediate layer density is either constant or varies exponentially across layer. First-order perturbation solution is discussed for thin layer as compared with perturbation wavelength. Stratified layer is unstable when accelerated in direction of increasing density. Author finds infinity of modes of internal instability which leave interface undisturbed. There are also two modes of interfacial instability similar to those occurring with constant density layer. Greatest rate of growth of disturbances is for one of the interfaced modes. I. Greber, USA

6180. Boyer, D. W., An experimental study of the explosion generated by a pressurized sphere, *J. Fluid Mech.* **9,** 3, 401–429, Nov. 1960.

See AMR **12**(1959), Rev. 2483.

Boundary Layer

(See also Revs. 6160, 6198, 6202, 6217, 6260, 6297, 6307, 6340, 6342)

6181. Hassan, H. A., On skin friction in the slip-flow regime, *J. Aerospace Sci.* **28,** 4, 335–336 (Readers' Forum), Apr. 1961.

Incompressible boundary layer flow with slip and pressure gradient is studied. Skin friction is given in closed form as a series of ascending powers of $x^{1/2}$ (x distance to the leading edge) so far as $x^{3/2}$. Two methods have been used for this problem in

the past: (1) perturbation of usual boundary-layer flow; (2) analogy with solution of Rayleigh problem of the impulsive motion of a flat plate. Present paper belongs to the second group of methods.

J. P. Guiraud, France

6182. Cooke, J. C., Approximate calculation of three-dimensional laminar boundary layers, Aero. Res. Counc. Lond. Rep. Mem. 3201, 30 pp., 1961.

Three different approximate methods of solving the three-dimensional laminar boundary-layer equations are tested on a problem whose exact solution is known. From the comparison one of the methods, which is developed in this paper, is recommended as the one to use in general, provided that the crossflow in the boundary layer is not large.

The method is tested on two allied problems whose exact solution is known; fair agreement is obtained.

Finally the three methods are used to find the angle between streamlines and limiting streamlines for the flow over a slender delta wing, and to determine the point of separation.

From author's summary

6183. Dorodnitsyn, A. A., One method of solution of the equations of the laminar boundary layer (in Russian), *Zh. Prikl. Mekh. Tekh. Fiz.* **3**, 111–118, 1960.

A canonical form of the equations of the laminar boundary layer for an incompressible fluid is derived and an analog of Karman's integral relation is found for this canonical system. Based on this integral relation, a method of computing the solution of the system in any concrete case to any desired degree of accuracy is given. For use with an electronic computer a standard program is sufficient. The first four approximations are exhibited, and the numerical results they yield are compared with corresponding values of the actual solution. The results of a sample computation of the characteristics of the boundary layer are presented. The method can be applied to the case of a compressible gas, only the calculations become more complicated.

N. D. Kazarinoff, USA

6184. Dem'ianov, Iu. A., and Shmanenkov, V. N., Investigation of reverse flows in the region of separation of the turbulent boundary layer, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **24**, 2, 340–343, 1960. (Pergamon Press, 122 E. 55th St., New York 22, N.Y.)

The separated region in supersonic flows upstream of a forward-facing step or on a sting attached to a blunt body are treated by a simplified model based on free, turbulent mixing, two-dimensional and conical, respectively. The prediction of the angle formed by the separation zone is found in each case to be in good agreement with experiment.

P. A. Libby, USA

6185. Walz, A., Contribution to the approximation theory of compressible turbulent boundary layers: Part 2, Calculation of universal functions and examples (in German), Dtsch. Versuchsanstalt Luftfahrt, Ber. 136, 54 pp., Oct. 1960.

Further development of previous method [AMR **14** (1961), Rev. 333] for compressible laminar and turbulent boundary layers. Universal functions in energy and momentum differential equations are described by simple expressions in terms of velocity-profile shape factor, Mach number, and heat-transfer factor. Results of method applied to flat plates show good agreement with existing test data.

P. S. Granville, USA

6186. Spence, D. A., The growth of compressible turbulent boundary layers on isothermal and adiabatic walls, Aero. Res. Counc. Lond. Rep. Mem. 3191, 15 pp., 1961.

A recent study of velocity profiles in the turbulent boundary layer on a flat plate at high Mach numbers has suggested the formula

$$H = \frac{T_w}{T_e} H_i + \frac{T_r}{T_e} - 1$$

for relating the form parameter H to its incompressible value H_i (T_w, T_e, T_r are the wall, free-stream and recovery temperatures). This formula is used in conjunction with a generalization of the Stewartson-Illingworth transformation to reduce the left-hand side of the integral momentum equation (including pressure gradients) to incompressible form, for arbitrary values of the flat-plate recovery factor (or of the turbulent Prandtl number), which is about 0.89 for air. The intermediate temperature formula of Eckert is used to relate the skin friction to its incompressible value, for which a $1/n$th power law is used. The momentum equation is then integrable when H_i is given a constant value, which may be chosen to secure agreement in the incompressible case with Maskell's quadrature for the momentum thickness θ, or with the author's modification of the latter. The integration is carried out for the cases of zero heat transfer and of a constant-temperature wall, the details of the Stewartson-type transformation being slightly different in the two cases, but the final forms for

$$\Theta = \frac{\rho_e}{\rho_m} \left(\frac{\rho_e u_e \theta}{\mu_m} \right)^{1/n} \theta$$

are the same:

$$\Theta M^B F(M) = (\text{const}) \int M^B F(M)\, dx.$$

The constant B depends in the second case on the ratio T_w/T_e of wall to total stream temperature, but $F(M)$ does not. This is of the same form as the equation obtained by Reshotko and Tucker in the special case of unit recovery factor. A numerical example shows results very close to those obtained by Young's method, which involves two quadratures, in a particular case at zero heat transfer. Some calculations have also been made to illustrate the effect of cooling the wall on the boundary-layer growth in a pressure gradient.

From author's summary

6187. Cooke, J. C., A calculation method for three-dimensional turbulent boundary layers, Aero. Res. Counc. Lond. Rep. Mem. 3199, 19 pp., 1961.

A method for the calculation of three-dimensional turbulent boundary layers is given. It depends on the assumptions that the component of the velocity in the boundary layer parallel to the external streamlines follows a power law, and that the angle the direction of flow in the boundary layer makes with the external streamlines is small.

The external flow is expressed in streamline coordinates and the calculations follow a streamline in the external flow. The momentum thickness is determined by a quadrature and the angle the limiting streamlines make with the external streamlines is determined from a linear differential equation.

Only slight experimental checks are available; they suggest that the method is adequate, but more experimental results are needed in order to refine the method.

From author's summary

6188. Yang, K.-T., An improved integral procedure for compressible laminar boundary-layer analysis, *ASME Trans.* **83** E (*J. Appl. Mech.*), 1, 9–20, Mar. 1961.

Method is based upon a transformation of independent variables which converts the original boundary-layer equations into an uncoupled pair of partial differential equations for the velocity and temperature, with coefficients which depend upon the assumed polynomial velocity and temperature profiles used in the usual

integral method. These equations can be integrated by quadratures to give improved velocity and temperature profiles.

The improved procedure is applied to four cases for which exact numerical solutions are known: the Blasius solution for the insulated plate, the Chapman-Rubesin solution for a flat plate with variable surface temperature, the Cohen-Reshotko similarity solution with heat transfer and pressure gradient and to Stewartson's problem of prediction of laminar separation when the velocity distribution is linear. There is considerable improvement over the usual integral method in these cases, especially in the first and second derivatives of the profiles. However, at least three of these are similarity solutions of the boundary-layer equations to begin with, and consequently this paper, in the reviewer's opinion, does not show whether or not method leads to definite improvement in nonsimilar cases. R. E. Street, USA

6189. Bushmanov, V. K., Hydrodynamic stability of a liquid layer on a vertical wall, *Soviet Phys.-JETP* **12**, 5, 873–877, May 1961. (Translation of *Zh. Eksp. Teor. Fiz., Akad. Nauk USSR* **39**, 5 (11), 1251–1257, Nov. 1960 by Amer. Inst. Phys., Inc., New York, N.Y.)

The flow of a layer of fluid down a vertical wall is of practical interest, particularly in chemical engineering applications. Under certain conditions waves form on the surface of the layer, markedly affecting its behavior. Kapitza gave an approximate theoretical analysis which indicates that surface waves were stable at Reynolds numbers above 21.6 and reported experiments confirming this value. The second section of this paper giving a condensed account of Kapitza's analysis is of some interest since the original report was in Russian.

The first section of the paper examines the stability of undisturbed flow. The critical Reynolds number is estimated as 72. It is pointed out that this does not contradict Kapitza's results as the Reynolds number for the appearance of waves may be higher than the Reynolds number for their disappearance, i.e. hysteresis may be involved.

However, in the third section a more precise analysis is given of the stability of the waves. This leads to a reinterpretation of Kapitza's measurements to give a critical Reynolds number of 64.

Reviewer feels that further experimental and theoretical work is needed on this problem. W. Squire, USA

6190. Wasko, R. A., Experimental investigation of stage separation aerodynamics, NASA TN D-868, 24 pp., May 1961.

Interstage aerodynamic pressures on a two-stage missile model with a cold-air simulated second-stage rocket motor were investigated over a range of separation distances to 3 second-stage body diameters at Mach 2 and a pressure altitude of 38,000 ft in the 8- by 6-ft tunnel. Effects of stage centerline misalinement were also studied. First-stage interference effects produced higher-than-ambient second-stage base pressures over a longer separation distance for jet-off staging than for jet-on. Ports in the interstage fairing for jet-on staging reduced the range of interference effects and also reduced but did not eliminate fluctuating second-stage base and afterbody pressures.

From author's summary

6191. Spangenberg, W. G., and Rowland, W. R., Optical study of boundary-layer transition processes in a supersonic air stream, *Physics of Fluids* **3**, 5, 667–684, Sept./Oct. 1960.

Authors use cylindrical lens camera to magnify thickness of boundary layer, thereby permitting observation of details of boundary-layer transition. Sequential spark schlieren system shows breakdown of laminar boundary layer occurs through accumulation of turbulent spots. Results suggest turbulent spots originate from amplification of Tollmien-Schlichting waves.

Results replace the concept of transition as a self-sustaining feedback process by the concept of transition as a spontaneous, spotty, cumulative degeneration of the laminar boundary layer.

E. W. Price, USA

6192. Curle, N., Heat transfer and laminar-boundary-layer separation in steady compressible flow past a wall with non-uniform temperature, Aero. Res. Counc. Lond. Rep. Mem. 3179, 16 pp., 1961.

Author's method for compressible laminar boundary layers, in which a linear viscosity-temperature relationship and a Prandtl number of unity are assumed, is used to investigage some cases in which the wall temperature is not uniform. It is shown that the effect of wall-temperature distribution does not make any essential difference to the method. For example, according to the basic method separation occurs when the pressure-gradient parameter reaches a certain value. The values of this parameter for a wall-temperature distribution $T_w(x)$ are derived from the values for uniform temperature $T_w(0)$ by direct multiplication by $T_w(x)/T_w(0)$.

An alternative and longer, but theoretically more acceptable, expression is derived for the boundary-layer momentum thickness. This expression is obtained by using a kinetic-energy integral equation, in which the momentum equation is multiplied by the local velocity before being integrated across the boundary layer. Accordingly the assumed approximate temperature profile, which is at least accurate near to the wall, affects the solution of the momentum equation only through integrals in which small contributions come from near to the wall.

The method is used to examine the problem of heat transfer through a laminar boundary layer with zero pressure gradient, when the wall temperature is a polynomial in x. The predicted heat transfer agrees well with the known exact value when the wall temperature does not vary too rapidly in space. In particular, for wall temperatures like x^n, it is about 40 per cent too high when $n = \frac{1}{2}$, 20 per cent too high when $n = 1$, almost exact when $n = 2$, 20 per cent too low when $n = 4$ and 40 per cent too low when $n = 10$.

The method is then used to consider a problem of cooling by radiation at high Mach number when a uniform stream is assumed and the wall temperature determined by the balance between heat transfer to the wall and radiation from it. Whereas an accurate earlier solution for the wall temperature had required the solution of a nonlinear integral equation, the present method yields a simple algebraic equation. Nevertheless, the error in the predicted wall temperature varies from zero at the leading edge to only 18 per cent infinitely far downstream.

Some consideration is then given to the effects of nonuniform wall temperature on boundary-layer separation. Some examples are worked out, illustrating the delay in separation when the wall temperature decreases from the leading edge, as is the case in problems of cooling by radiation. Further, estimates are made of the cooling required to completely suppress separation. These results have been calculated by both the basic and lengthier methods, and indicate that the simpler basic method will be adequate in many practical cases.

Finally, since the assumed approximate temperature profile is obtained by downstream integration from the pressure minimum, and is severely in error near to a forward stagnation point, it is indicated that a method due to Cohen and Reshotko should give accurate results for flow upstream of the pressure minimum. It is shown in this paper that even in the case of variable wall temperature, the differential equation arising in their method may be integrated by two simple quadratures in regions of favorable pressure gradient. Accordingly their method is recommended for use upstream of the pressure minimum, where a convenient join can be

made with the present method, which should give the more accurate results downstream. From author's summary

6193. Wallis, R. A., A preliminary note on a modified type of air jet for boundary layer control, Aero. Res. Counc. Lond. Curr. Pap. 513, 6 pp. + figs., 1960.

An attempt has been made to develop a type of air jet which is capable of producing persistent vorticity for the purpose of delaying turbulent separation and, in particular, shock-induced separation. Experiments with circular jets, suitably pitched and inclined at an angle to the surface in the cross flow direction, show considerable promise. From author's summary

6194. de Soto, S., and Wolf, H., Application of the Mangler transformation in boundary layer flow, *ARS J.* **31,** 4, 553–555 (Tech. Notes), Apr. 1961.

Application of Mangler's transformation to the laminar axisymmetric boundary layer on a circular cone with attached shock wave shows an increase in heat transfer by a factor $\sqrt{3}$ compared with the analogous two-dimensional boundary layer on a wedge. Authors prove that Mangler's transformation is not applicable to turbulent boundary layers so that no simple extrapolation procedure for determining the heat transfer from two-dimensional data is available in this case. E. Becker, Germany

6195. Mirels, H., Laminar boundary layer behind a strong shock moving into air, NASA TN D-291, 15 pp., Feb. 1961.

The laminar wall boundary layer behind a strong shock advancing into stationary air is investigated. Results of numerical computations for shock Mach numbers ranging from 4 to 14 are presented. The author developed approximate expressions for the boundary-layer thickness and displacement thickness and these expressions can be used for estimating flow nonuniformity in shock tubes. G. V. R. Rao, USA

Turbulence

(See also Revs. 6172, 6184, 6191, 6290, 6307, 6389, 6390)

6196. Nevzglyadov, V. G., Thermodynamics of turbulent systems, *Soviet Phys.-JETP* **12,** 6, 1206–1210, June 1961. (Translation of *Zh. Eksp. Teor. Fiz., Akad. Nauk USSR* **39,** 6 (12), 1727–1733, Dec. 1960 by Amer. Inst. Phys., Inc., New York, N. Y.)

A generalization of the second law of thermodynamics applicable to turbulent systems is obtained by averaging the equations of irreversible thermodynamics. The procedure is similar in principle to that used by Blackadar [*J. Meteorology* **12,** p. 165, 1955] but the results differ somewhat.

Reviewer was not able to resolve the discrepancy but notes that Blackadar's definition of the eddy entropy cited in Eq. 3.14 of the present paper (Eq. 35 of Blackadar's) seems inconsistent dimensionally. Both papers are rather abstract and the engineering applications not readily apparent. W. Squire, USA

6197. Monin, A. S., On Lagrangian characteristics of turbulence, *Soviet Phys.-Doklady* **5,** 5, 952–956, Mar./Apr. 1961. (Translation of *Doklady Akad. Nauk SSSR (N. S.)* **134,** 2, 304–307, Sept. 1960 by Amer. Inst. Phys., Inc., New York, N. Y.)

Theoretical formulation of turbulent diffusion problems in terms of probability densities of velocities and positions of fluid particles. Author considers problems in fixed coordinates and in coordinates moving with a fixed velocity or with the velocity of a single fluid particle. One of latter approaches is preferred for atmospheric diffusion because only local hydrodynamical characteristics referred to moving coordinates can be considered statistically stable; the grosser aspects of the motion are not "finely sealed" enough to be treated by statistical laws applying to homogeneous locally isotropic turbulence. No data or direct reference to engineering applications is given; several typographic errors appear in the translation. F. I. Badgley, USA

6198. Baldwin, L. V., and Walsh, T. J., Turbulent diffusion in the core of fully developed pipe flow, *AIChE J.* **7,** 1, 53–61, Mar. 1961.

Mathematical development, instrumentation used, data, detailed results and discussion of results in relation to other work in the field, are given for an experimental study of turbulent diffusion downstream of a line source of heat. Objectives of the study were to find relations between Eulerian description of the turbulence and the Lagrangian statistical properties and to determine the behavior of the eddy diffusivity in the diffusion field. Reviewer believes care was taken in designing the experiment, instrumentation was adequate, application of theory correct, and general conclusions supported by data.

Authors' summary presents results as: "... diffusion results agreed with predictions of G. I. Taylor's theory of diffusion by continuous movements. The eddy diffusivity increased from zero at the heat source to a constant asymptotic value for downstream. The Lagrangian correlation coefficients inferred from the diffusion data had shapes similar to the Eulerian correlations over most of the range of time and space. Empirical relations were found to relate the coordinates of the ... correlation coefficients over the range of this experiment.... Preliminary measurements are reported for a general Eulerian correlation which is a function of both space and time; the results indicate that a special case of this new Eulerian function may be fair approximation of the Lagrangian correlation." W. Rice, USA

6199. Taranova, G. M., The invariant in the theory of axially-symmetrical anisotropic turbulence (in Russian), *Naucbn. Dokladi Vyssh. Shkoly. Fiz.-Matem. Nauk* no. 2, 114–116, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13740.

Let $Qig = u_i(x)\, uj(x')$ be the correlational tensor of axially symmetrical turbulence studied in the works of Chandrasekhar [S. Chandrasekhar, *Phil. Trans. Roy. Soc., Land.* (*A*) **242,** 557–577, 1950; *Proc. Roy. Soc., Lond.* (*A*) **203,** 358–364, 1950]. As turbulence of this nature is homogeneous (but not isotropic) it is found that $Qij = Qig(\xi)$, $\xi = x^1 - x$. With the aid of the general equation for the second and third functions for the moment (an analogy would be the Harman-Howarth equations in the theory of homogeneous and isotropic turbulence) it is demonstrated that in conditions of a sufficiently rapid diminution of some scalar functions of the moment to infinity (with $|\xi| \longrightarrow \infty$) the integral

$$\Lambda = \int_v Qij(\xi)\xi i\ \xi j = d\tau$$ ($d\tau$ being an element of volume) remains

constant in the process of degeneration of the turbulence. The integral Λ differs only by its constant multiple from the expression

$$\int_v Qii(\xi)\, \xi^2\, d\tau = -2\Lambda$$ equal to the total moment of the quantity of

motion of the turbulent flow; in the isotropic case it is transformed into the known Loitsianskii invariant. A. M. Yaglom

Courtesy Referativnyi Zhurnal, USSR

6200. Frost, V. A., Rapid homogeneous deformation of turbulence in a gas, *Soviet Phys.-Doklady* **5,** 4, 690–693, Jan./Feb. 1961. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* 133, 4, 773–776, Aug. 1960 by Amer. Inst. Phys., Inc., New York, N. Y.)

Aerodynamics

(See also Revs. 6124, 6139, 6146, 6152, 6155, 6157, 6158, 6159, 6160, 6161, 6162, 6163, 6164, 6165, 6167, 6173, 6174, 6175, 6177, 6179, 6181, 6336, 6352, 6370)

6201. Kulakowski, L. J., and Haskell, R. N., Solution of subsonic nonplanar lifting surface problems by means of high-speed digital computers, *J. Aerospace Sci.* **28,** 2, 103–112, 176, Feb. 1961.

Theory is based on linearized differential equation for small perturbation velocity potentials about trapezoidal airfoil sections with straight edges. Van de Vooren's integration method ["An approach to lifting surface theory," Netherland's NLL Rep. F 129, 1953] has been programmed for a 704 IBM computer by means of Fourier series. Computer time is given to average about 2 control points per minute. Results are found to be in good agreement with other theoretical data (Multhop, Garner), Malavand's electrical tank, and wind-tunnel measurements.

H. K. Beckmann, USA

6202. Jain, A. C., On compressible boundary layer on a flat plate with uniform suction, *Proc. Indian Acad. Sci.* (*A*) **53,** 1, 12–27, Jan. 1961.

A comparative study of Lew's quartic profile and exponential profile, together with the quartic profile of the present paper has been made; the graphs for the various characteristics of the flow for several Mach numbers and suction coefficients have been drawn.

From author's summary by A. N. Petroff, USA

6203. Carafoli, E., and Nastase, Adriana, Minimum drag trapezoidal wing in supersonic flow (in Russian), *Mebanika* (Izdatelstvo Inostranoi Literaturi) 1 (65), 69–77, 1961.

Authors determine the shape of the surface of a minimum-drag thin wing of trapezoidal planform, whose lift and pitching moment are given. The suction forces occurring on the lateral leading edges are included in the drag calculation. The variational method of Lagrangian multipliers is applied.

The use of a convenient formula for the axial disturbance velocity u (see *Rev. Mécan. Appl.* **2,** no. 1, 1957) established within high-order conical motions has permitted the problem to be systematized in such a manner that for any position of the leading edges with respect to the Mach cone, the problem of determining the shape of the surface of the minimum drag wing depends on the calculation of a simple type of integral for which authors give a simple algebraic recurrence formula.

It is shown that the same procedure can be applied for complex systems of wings fitted with normal plates, ailerons and so on.

L. Dumitrescu, Roumania

6204. Medukhovskii, I. B., On the aerodynamics of fin-stabilized axisymmetric bodies at angle of attack, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **25,** 3, 561–566, 1961. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

This misnamed paper concerns itself with following in detailed functional form the consequences of symmetries of a body with and without control surfaces. The characterization of the flow field enters only through the fundamental assumption that the aerodynamic attributes under consideration are expressible as truncated Taylor series of order n in the direction cosines, e_y and e_z, of the angle between the free-stream velocity and the axis of symmetry of the body—the x axis. The angles of attack α and the roll β are introduced as natural for the study of symmetries, and use is made of trigonometric identities in order to reduce the powers of trigonometric functions to functions of multiple angles, exhibiting the periodicities more clearly. Ultimately, functional expressions are given for the fin-induced aerodynamic forces and moments on an axisymmetric body at an angle of attack when the effect of a single fin is given and the velocity is sufficiently supersonic to reduce the mutual interference between fins to nothing.

For implications of symmetry of bodies which also spin, see C. G. Maple and J. L. Synge, *Quart. Appl. Math.* **6,** 345–365, 1949; AMR **3,** (1950), Rev. 2529.

M. V. Morkovin, USA

6205. Belotserkovskii, O. M., On the calculation of flow past axisymmetric bodies with detached shock waves, using an electronic computing machine, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **24,** 3, 745–755, 1960. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Examples are worked out with the Dorodnicin method and results are given.

J. P. Guiraud, France

6206. Wani, T., Aerodynamic interference in a free-molecule flow, *Trans. Japan Soc. Aero. Space Sci.* **3,** 4, 13–20, 1960.

Perpendicular rectangular plates are studied as a simple geometry for interaction of "flow fields" at large Knudsen numbers. Pressure and shearing stress interferences are about 1% even at large speed ratios. Compensatory effects are increases due to reflections from, and decreases due to shielding of, the adjoining plate.

J. R. Baron, USA

6207. Wuest, W., Generalized similarity solutions of three-dimensional boundary layers (in German), *Mitt. Max Planck Inst. Stromungsforschung* no. 24, 76 pp., 1959.

A survey is given of similarity solutions in three-dimensional laminar boundary-layer flow. A similarity solution exists if the velocity profiles in all points of the wall depend upon only one similarity parameter $\zeta = \sqrt{Re}\, g(\alpha, \beta)\, z$, where Re = Reynolds number, $g(\alpha, \beta)$ a function depending upon the coordinates α and β at the wall and z the coordinate perpendicular to the wall. The conditions for the existence of similarity solutions in arbitrary orthogonal coordinates are derived with the result that the velocity components U and V outside the boundary layer as well as the function $g(\alpha, \beta)$ must be certain prescribed functions of α and β.

All possible similarity solutions are given for steady flow along a plane wall in the cases of rectangular and polar coordinates. Reviewer believes that solutions given in Sec. 3.24 for a rotating coordinate system are in error due to the omission of a factor g^{-2} in the expressions for a_s and b_s in Eqs. (10).

Similarity solutions for axial symmetric bodies exist if the body is of a certain specified form.

A second class of similarity solutions is investigated, viz. that where similarity exists only along certain curves instead of along the whole wall. Besides the parameter ζ, a second parameter denoting the curve of the family then occurs in the determination of the velocity profiles.

The conditions for unsteady similarity solutions are also investigated.

A large number of results obtained already by other authors are incorporated as special cases in the general theory of the present author.

In an appendix corrections are given for the Blasius solution in two cases, viz. (i) the leading edge of the plane wall is curved and (ii) the plane wall is placed in a shear flow.

A. I. van de Vooren, Holland

6208. Ross, A. J., The theoretical evaluation of the downwash behind jet-flapped wings, Aero. Res. Counc. Lond. Rep. Mem. 3119, 32 pp., 1961.

The downwash behind jet-flapped wings of infinite and finite span has been evaluated, using the solutions given by Spence and by Maskell for the flow in two and three dimensions respectively.

The wing incidence and jet deflection are assumed to be small, and the displacement of the jet is taken into account by displacing the downwash field so that the relative distance between the jet and tailplane is correct. It is also assumed that the spanwise loading on the finite wing is elliptic, and that the trailing vorticity is generated at one particular chordwise position. The wake is considered to be a flat sheet, and so the effect of the rolling-up of the wake has been neglected.

Charts are given for the functions required in the calculation of the downwash for four specific values of jet momentum coefficient. Results have been obtained for the infinite wing and for a wing of aspect ratio 6.0, for various tailplane positions, and varying wing incidence, jet deflection and jet momentum coefficient. A comparison is also made with some American experimental results for a wing of aspect ratio 8.4, and the agreement is good, especially when the experimental lift coefficient is used in the calculations (since it differs considerably from the theoretical lift value, owing to the fact that the experimental wing has a blown flap).

From author's summary

6209. Gersten, K., Calculation of non-linear aerodynamic stability derivatives of aeroplanes (in English), Dtsch. Versuchsanstalt Luftfahrt, Ber. 143, 33 pp., 1961.

A survey of the existing methods for calculating the nonlinear effects on lift and pitching moment for airfoils with small aspect ratio, and a new method for calculating lift distributions on wings with sharp leading edges in incompressible flow are presented.

From author's summary by A. N. Petroff, USA

6210. Olstad, W. B., Mugler, J. P., Jr., and Cahn, M. S., Static longitudinal and lateral stability characteristics of a right triangular pyramidal lifting reentry configuration at transonic speeds, NASA TN D-655, 62 pp., Apr. 1961.

The model was tested at Mach numbers from 0.60 to 1.19 at angles of attack up to 27.5°. The lower surfaces of the model had a dihedral angle of 45° and the upper surface was flat. Leading-edge sweep was 79.5°. The model was tested with and without a boattail afterbody. From authors' summary

6211. Kuhn, R. E., Review of basic principles of V/STOL aerodynamics, NASA TN D-733, 17 pp., Mar. 1961.

This paper reviews the principal factors that determine the performance of V/STOL aircraft. These can be summarized as follows. In hovering, the power required, the fuel consumption, and the downwash dynamic pressure are all determined by, and increase with, increasing slipstream area loading. In transition the wing span, the distribution of load on that span, and the power required in hovering determine the shape of the power-required curve and through this the engine-out safety and STOL performance. In cruise some compromises are required but, generally, the same rules for designing good cruise performance into conventional airplanes still apply to V/STOL configurations, namely, attention to aerodynamic cleanliness to reduce the parasite power and a wing of appreciable span to reduce the induced power.

From author's summary

6212. Goodson, K. W., and Otis, J. H., Jr., Effect of ratio of jet area to total area and of pressure ratio on lift augmentation of annular jets in ground effect under static conditions, NASA TN D-720, 46 pp., Mar. 1961.

An investigation in which the ratio of jet area to total area ranged from 1.00 to 0.02 and the pressure ratio ranged from about 1.04 to 1.95 was made in a static test room with use of the compressed-air facilities. Several configurations with center jets were tested through an angle-of-attack range to determine the pitching-moment characteristics. Calculations of the lift per air horsepower indicate that the greatest lift per air horsepower for a fixed base loading occurs at area ratios above 0.10, rather than at 0.10 where the greatest lift augmentation occurs.

From authors' summary

6213. Brooks, G. W., and Silveira, M. A., Some recent studies in structural dynamics of rotor aircraft, NASA TN D-737, 15 pp., Mar. 1961.

A summary of four studies of the structural-dynamics problems of rotor-powered aircraft is presented. These studies include the determination of the forces and moments at the hubs of various rotor configurations, the control of the natural frequencies of rotor blades by the use of multiple flapping hinges or flexjoints, the mechanical instability of rotors with inclusion of additional degrees of freedom in the rotor support, and the effect of stiffness and damping on the gyroscopic whirling instability of propellers.

From authors' summary

6214. Dean, R. C., Jr., and Senoo, Y., Rotating wakes in vaneless diffusers, *ASME Trans.* **82** D (*J. Basic Engng.*), 3, 563-574, Sept. 1960.

A simplified model of a rotating flow of variable velocity in a radial diffuser is analyzed. It is shown that in the case of rotating distortion patterns energy is transferred from the high-velocity region to the low-velocity region. The phenomenon is basic and will be of interest to all internal aerodynamicists.

D. V. Foster, USA

Vibration and Wave Motion in Fluids

(See also Revs. 5809, 6148, 6179, 6180, 6315, 6424)

6215. Alterman, Z., Effect of surface tension on the Kelvin-Helmholtz instability of two rotating fluids, *Proc. Nat. Acad. Sci. Wash.* **47**, 2, 224-227, Feb. 1961.

Author analyzes the characteristic equation for small oscillations of the common boundary of two superposed fluids with different horizontal velocities in the same direction. This equation is given without proof in the extended form for the case of uniform rotation with vertical axis and surface tension in the interface. The extension is ascribed to Chandrasekhar.

At a given difference between the velocities in the two layers the result is that rotation causes instability for long waves without appreciable influence of surface tension. The stability of short waves is influenced by surface tension only. The considerations are restricted to waves in the direction of the permanent currents. H. J. Schoemaker, Holland

6216. Harada, M., Steady and unsteady characteristics of fans and blowers, *J. Mech. Lab. Tokyo* **6**, 1, 27-41, 1960.

Author postulates a "flow vibration," of the Helmholz resonator type, in a generally stable fan-duct system, and derives the appropriate vibration period as

$$T = 2\Pi \sqrt{(|1 - \alpha_m| \rho l C / n P_m A)}$$

where $|1 - \alpha_m|$ is a parameter describing the fan characteristics.

The adequacy of the treatment is checked experimentally by observing vibrations in

1. a fixed fan-duct system, and
2. a fan-duct system with a small rotating baffle-plate in the duct giving a variable forcing frequency.

The concept is extended to flow vibrations in blade passages of an axial flow compressor. These vibrations are experimentally verified and are claimed as the cause of surge hysteresis.

Reviewer had difficulty in following many of the arguments because the author was not at ease with the English language.

F. G. Blight, Australia

6217. Dikii, L. A., On the stability of plane parallel flows of an inhomogeneous fluid, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **24,** 2, 357-369, 1960. (Pergamon Press, 122 E. 55th St., New York 22, N.Y.)

Author discusses the problem of the stability of plane parallel flows of an inhomogeneous fluid (with density varying in a direction transverse to the basic flow).

The motion is considered stable if an arbitrary initial disturbance arising in a first region of space remains bounded as time increases. He gives a complete mathematical solution by means of the Laplace transformation of a two-dimensional horizontal flow in an unbounded half-space the velocity V of which increases linearly with height and the density ρ_0 of which decreases exponentially:

$$V_{(z)} = kz; \quad \rho_0 = \text{const } e^{-\beta z}$$

Author shows that the solution is stable for all positive values of the Richardson number $R = g\,\beta/k^2$.

J. Polasek, Czechoslovakia

6218. Meier, H., Gravity waves in ideal liquids (in German), *Schiffstechnik* **7,** 39, 206-210, Nov. 1960.

Attempt is made to find pressure distribution in a plane wave from a simplified diagram. Assumptive restrictions made on wave kinematics are drastic, hurt continuity equation and admit vorticity. Author's idea of energy transport deviates from classical conceptions.

Reviewer would recommend this paper to a student rather than to an engineer.

K. Eggers, Germany

6219. Whitham, G. B., A note on group velocity, *J. Fluid Mech.* **9,** 3, 347-352, Nov. 1960.

The kinematic approach to group velocity given by Lighthill & Whitham [AMR **9**(1956), Rev. 361] for one-dimensional waves is extended to cover the general three-dimensional case. The ideas have particular bearing on the theory developed by Ursell [*J. Fluid Mech.* **9,** 333-46, 1960] for treating steady wave patterns on nonuniform steady fluid flows.

While all the main ideas presented are implicit in the book by Landau & Lifshitz [AMR **14**(1961), Rev. 870], they do not seem to be well known to fluid dynamicists, and the paper serves its original purpose of providing a supplement to Ursell's paper.

From author's summary by S. R. Montgomery, England

6220. Rumiantsev, B. N., On the unsteady motions of a heavy fluid at a sloping beach, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **24,** 3, 816-822, 1960. (Pergamon Press, 122 E. 55th St., New York 22, N.Y.)

The Cauchy-Poisson problem is considered for linearized gravity waves on a beach of constant slope. The potential is expanded as an integral of standing-wave modes; for a beach-angle of 45° the problem is treated in detail. The initial surface impulse must be expanded in terms of the surface values of the standing-wave modes, and the author makes the interesting remark that this can be done by an inversion theorem of Fourier type. Asymptotic expansions are given. The author also treats the small-angle problem by the linearized shallow-water theory.

F. Ursell, England

6221. Berzon, I. S., Variation of the amplitude of waves with distance in the case of reflection from a thin layer (in Russian), *Trudi Inst. Fiz. Zemli Akad. Nauk SSSR* no. 6 (173), 107-113, 1959.

6222. Cherkesov, L. V., On surface waves of a liquid (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 2, 37-45, 1959.

6223. Ratnikova, L. I., Surface waves registered close to a source (in Russian), *Trudi Inst. Fiz. Zemli Akad. Nauk* no. 6 (173), 253-282, 1959.

6224. Tsao, S., Waves on the surface of a fluid subject to the action of a central force (in Russian), *Zh. Prikl. Mekh. Tekh. Fiz.* **3,** 90-96, 1960.

6225. Epinat'eva, A. M., Certain analytical formulas for the amplitude of refracted waves (in Russian), *Trudi Inst. Fiz. Zemli Akad. Nauk SSSR* no. 6 (173), 7-51, 1959.

6226. Guyot, Mrs. M. T., Nougaro, J., and Thirriot, Cl., Numerical study of transient conditions in canals (in French), *Houille Blanche* **15,** no. B, 814-832, Dec. 1960.

Numerical calculation on an IBM 650 computer of the propagation of surges in open channels, assuming: (1) division of the flow in successive steps, (2) negligible vertical accelerations, (3) small deviations from the initial water level.

From Saint-Venant's continuity and dynamic equations the following methods are developed:

a. Numerical transposition of a graphical method presented by Nougaro, 1955 [IAHR Bull. Sixth meeting, paper D5, The Hague, 1955].
b. A method directly based on the theory of characteristics which, though more complex, is also more accurate.

From authors' summary by H. T. Kristensen, Sweden

6227. Belueva, A. S., Destruction of waves during the motion of the liquid in an open channel (in Russian), *Trudi Leningrad Gidrometeorol. In-ta* no. 7, 122-128, 1958; *Ref. Zh. Mekh.* no. 10, 1959, Rev. 11742.

In mathematical hydraulics many types of results obtained for gas dynamics are utilized, on the basis of the analogy of the equations for shoal water and gas dynamics. In particular, the well-worked-out methods for the approximate computation of the parameters of a flowing gas, based on an approximation of the equation for state, find application. In the work being abstracted the possibility is indicated of an analytical solution of a series of problems on the propagation of long waves, provided the relation of the transverse section F to the depth H can be approximated by the expression $F = A\,(H + C)^{3/2}$. These methods are illustrated by two examples: the problem on the formation and propagation of waves of the "bore" type with complete destruction of the dam, and the problem on the destruction of a simple wave. It is essential, in order to ensure the effectiveness of the method, that the character of the impact wave (the surface of the "bore") should be such that the magnitude $F(H) / F'(H)$ in transition over the surface of the impact wave should not change appreciably.

N. N. Moiseev
Courtesy Referativnyi Zhurnal, USSR

6228. Shankin, P. A., A study of waves produced by ships moving in a canal (in Russian), *Rechn. Transport* **1,** 3, 293-297, 1958; *Ref. Zh. Mekh.* no. 10, 1959, Rev. 11744.

A hydraulic solution is furnished for the problem on the determination of the height of the waves (and of the lowering of the water level) in a canal when a ship is in motion in it. The solution is based on the practical possibility of the application of Bernoulli's equation to the whole flow of liquid in the canal; consequently, instead of the actual distribution of velocities over the

canal's section averaged values of various factors (viscosity, curvature of the currents flowing about the ship's hull, and so forth), which are not reflected in a clear form in the expression obtained, are carried out with the help of empirical coefficients; their values are determined on the basis of data obtained from natural observations. A comparison of the magnitudes of the dimensions of ship's waves in canals obtained by the author of the paper with the data of other investigators showed that the approximation of his calculation data to the experimental was better than in the case of magnitudes determined by existing calculation formulas.

A. A. Kostyukov

Courtesy Referativnyi Zhurnal, USSR

6229. Shamina, O. G., An investigation of the dynamic features of longitudinal waves in layers of different thickness, *Bull. Acad. Sci., USSR, Geophys. Ser.* no. 8, 754–760, Feb. 1961. (Translation of *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 8, 1135–1148, Aug. 1960 by Amer. Geophys. Union, Washington 5, D. C.)

The dynamic features of longitudinal pulse waves are investigated in a free layer and in a layer immersed in water. It is shown that the velocity, form, dominant period and attenuation of a sliding wave in a free layer and a head wave from a layer in water are dependent on the thickness of the layer. The thinner the layer, the less will be the distance from the radiator within which it can be treated as a plate. The behavior of the wave amplitude is the most reliable indication that a longitudinal wave propagated in a layer with a velocity equal to the velocity in the plate is fully formed.

From author's summary

6230. Hayashi, T., and Ransford, G., Sudden opening or closing of an outlet valve on a pipeline (in French and English), *Houille Blanche* **15,** 6, 657–673, Nov. 1960.

The paper deals with damping of water hammer waves in long conduits. The method used is, in principle, that suggested by Bergeron, the graphical treatment suggested by this author being replaced by computations on a digital computer.

Many problems of water hammer concerning hydro-power systems are dealt with, ignoring the influence of pressure losses caused by friction. These may be very important in long water mains and distribution pipes, and also when plastic materials are used for the pipe instead of elastic steel.

Authors use the equation of Allievi (Water hammer), introducing the friction loss H_f for steady flow conditions. The cases of sudden closing and sudden opening are calculated for different parameters $\rho = aV/2gH$ (notation of Allievi).

The friction losses are supposed to be concentrated at m points along the conduit, m varying from $m = 1$ to $m = 15$. The paper shows the importance of choosing a high value m, especially for low values of ρ.

The variations of the velocity at the pipe outlet are also studied systematically. Diagrams summarize the main results for $m = 1$ to $m = 15$, and varying values ρ.

C. Jaeger, England

6231. Zhamagortsyan, V. N., Motion of a wave along a lateral spillway (in Russian), *Izv. Akad. Nauk ArmSSR Ser. Tekhn. Nauk* **11,** 5, 3–16, 1958; *Ref. Zh. Mekh.* no. 10, 1959, Rev. 11745.

A sudden stoppage of the motion of the water at the end of a derivational canal results in the production of a wave, propagating in a direction opposite to that of the motion of the water and overfilling the canal. In order to reduce the wave's height a lateral spillway is used. A solution of the problem is given regarding the unsteady motion of the wave along the spillway, a hydraulic setting for the problem being used, that is, on the assumptions that in the transverse section of the canal all the parameters are constant; here, the discharge of liquid varies from point to point. It is considered that initially the wave is formed like a step. Simple formulas are obtained as the result for the determination of the height and the velocity of the wave, and the ensuing investigation is described. The formulas are confirmed by the experimental work.

B. N. Rumyantsev

Courtesy Referativnyi Zhurnal, USSR

6232. Metelitsyna, G. G., and Plakida, M. E., Wave pressure and the height of the rolling out of the wave on steeply inclined walls (in Russian), *Trudi Tsentr. Nauk-i. In-ta Ekon. i Ekspluat. Vodn. Transp.* no. 15, 35–48, 1958; *Ref. Zh. Mekh.* no. 10, 1959, Rev. 11758.

An exposition on the experimental laboratory investigations of the interaction of waves with a steeply inclined wall. With waves with steepness ratios of $l = 12$, $l = 16$, $l = 35$ the investigations deal with the free surface of the waves, the wave pressure on the wall, the height of the splashing on the wall. It is explained that wave pressure on a steeply sloping wall is less than on a vertical wall. A formula is given for the calculation of the height of the run of the wave at the wall, which was obtained on the assumption that it was linearly dependent on the angle of inclination of the wall α, coinciding with $\alpha = 45°$ and $\alpha = 90°$ with the theoretical formulas of Senflu and Misha and agreeing satisfactorily with experiment.

S. V. Zhak

Courtesy Referativnyi Zhurnal, USSR

6233. Marchenko, B. M., Some questions concerning the calculations for air arresters (in Russian), *Naucbn. Trudi Leningr. In-ta Tochnoi Mekh. i Optiki* no. 32, 88–96, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13342.

A calculation is carried out for a piston-equipped air arrester for the case of a pure adiabatic process in which small changes in the air pressure are investigated. The author disregards the inertia of the air mass in the equation for motion while the viscosity coefficient is taken to be a constant magnitude. An ordinary linear differential equation of the third order with constant coefficients is obtained by resolving the equation for the adiabate into a series and by discarding magnitudes of the second order of smallness. From the solutions found an investigation is made of the vibrational motion of a system and of the motion with boundary aperiodic damping. A comparison of the obtained results with the solution for a pure isothermal process showed that in a case where no reliance can be placed on the adiabatic thermal process in the arrester the calculation should be carried out by the isothermal process. This gives a more reliable result. Formulas are derived for the calculation of the displacement phase between the pressure and the velocity for the isothermal and the adiabatic processes.

L. Ya. Khaskin

Courtesy Referativnyi Zhurnal, USSR

6234. Kunin, I. A., On the theory of a planetary vibrator in an infinite fluid medium (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 5, 48–52, 1959.

6235. Ivanova, T. G., Experimental data concerning the influence of layers in the apex on the exit angle of waves of various frequencies (in Russian), *Trudi Inst. Fiz. Zemli Akad. Nauk SSSR* no. 6 (173), 195–212, 1959.

6236. Kolchev, P., Surge tank stability in certain complex cases (in French), *Houille Blanche* **15,** 6, 678–689, Nov. 1960.

The same group of problems has been dealt with extensively by Jaeger ["Water Power", Vol. 9, July/August 1957; *Trans. ASME* **80,** 1574–1584, 1958], Zienkiewicz [*Proc. Instn. Mech. Engrs.* **170,** 265–280, 1956. See also AMR 9(1956) Rev. 2241], and Sideriades [*Houille Blanche* **13,** 447–449, Aug./Sept. 1958]. These four pa-

pers are more general and cover a wider field than that by Kaichev. They are all based on the discussion of the same equation of the fourth order.

Specialists will nevertheless find P. Kaichev's paper worthwhile reading because of some interesting remarks and a good summary of the problem as a whole. C. Jaeger, England

6237. Bourdon, C., Contribution to the study of constricted orifice surge tanks by the graphical method (in French), *Genie Civ.* **137,** 17, 360–364, Sept. 1960.

A graphical method is derived for the solution of the differential equation describing the surge tank oscillation. Its use is demonstrated for cases of load demand and load rejection.

W. D. Baines, Canada

Fluid Machinery

(See also Revs. 6126, 6127, 6152, 6216, 6260, 6318)

Book—6238. Goflin, A. P., Aerodynamic calculation of the blade and inner casing systems of stationary axial flow compressors, (in Russian), Moscow-Leningrad, Mashgiz, 1959, 301 pp. 13r25k.

Author states that present calculating methods of axial-flow compressors do not permit estimating with sufficient accuracy the real characteristics of a single-stage machine. For this reason it is also impossible to calculate accurately the characteristics of a multi-stage compressor. Experimental investigations indicate, however, fair accordance between experiments and calculation when basic stage is calculated by one of present methods and then further developed through experiments. If experimental characteristics of such basic stage are considered as general data for calculations of a multi-stage machine and calculations with respect to the theory of similarity are made, then agreement of experimental and computed characteristics of a multistage machine is very satisfactory. Method and the procedure of these calculations are clearly described and explained in the book.

The subject matter is presented in a succession of 10 chapters with an appendix in 4 parts. Chapter 1 deals with basic relations in an elementary stage and is in fact a survey of general knowledge. The following two chapters treat the aerodynamic calculation of a single stage which is later considered to deliver basic data through experimental investigation. The method of calculation, using the assumption of the flow on concentric cylindrical surfaces, is based on the applications of experimental results on airfoil cascades in the well-known Howell's manner. At the end of Chapter 3 author concludes it is impossible at present time to estimate by calculation only and with satisfactory accuracy real characteristics of the stage including the velocity and pressure field. It is therefore necessary, according further to author's statement, to translate the obtained experimental characteristics to the calculated ones and improve the stage through experiments on the rotating model.

As an introduction to that method Chapter 4 deals with fundamentals of the transfer of experimental results from model stage into reality. Paragraphs of this chapter refer to the dynamic similarity factors and specially to the influence of Reynolds number and relative roughness on the stage characteristics.

Chapter 5 treats the influence of some design parameters on characteristics of single stage. To preserve equality of basic dynamic similarity factors the investigator is pressed to accept quantities of various design parameters on model stage which differ from those of real stage because there are deviations in geometric similarity due to the reduction of dimensions on the model. Therefore an analysis of influence of radial gap, axial distance of blades system, blade aspect ratio and solidity is made.

In similar manner Chapter 6 treats the influence of the flow and entering conditions on the basic stage characteristics. The effect of entering pressure, temperature and velocity distribution and also the calculation of surge line is analyzed.

Finally, the last 4 chapters deal with design methods of blading and inner casing system of multi-stage compressors and with calculating of these machines on basis of experimental characteristics of basic model stage.

In Chapter 7 author first describes various shapes and types of blading system according to the composition of multi-stage machine from the same or different basic stages, to the constant or variable design diameter, to the variability of inner and outer diameter and to the manner of shortening of blades. Five types of blading and inner casing system are described, their essential computed parameters are presented and briefly discussed.

Chapter 8 deals with the effect of the distribution of discharge coefficient in multi-stage machine on the characteristics of compressor.

In Chapter 9 the computing method used in CKTI Leningrad is given and generally explained by the design calculations of a multi-stage machine. The method is successful if the designer has at his disposal a lot of experimental data of basic single stages. The calculation consists of two steps: of a preliminary calculation delivering the number of stages, dimensions of blades in the first and in the last stage including the efficiency of the blading system, and of one or two final calculations. The purpose of the latter is to determine whether the chosen stage is giving satisfactory general performance of the assumed machine and to improve it, if necessary, by considering another basic stage in second calculation. After these calculations have been made, further calculations of static pressures, temperatures, adiabatic efficiency and actual work done follow.

Last chapter, 10, treats the calculation of characteristics of multi-stage compressor according to the known single-stage characteristics.

Three parts of the appendix contain as examples complete calculations of three compressors each having 13, 10 and 9 stages respectively with degree of reaction of 1, 0.5 and 0.5, respectively. The necessary experimental data of chosen basic single stages were taken from the fourth part of the appendix entitled "Atlas of basic single stages." This atlas includes fundamental data and characteristics for the aerodynamic and stress calculations. Data are collected from 5 single-model stages with degrees of reaction of 0.5, 0.7 and 1.

The text of the book is clearly written without surplus details and is of importance to design and computing engineer. Reviewer considers, however, the briefness of the text has led to the large number of paragraphs with apparent little mutual relation. Thus, on first study, the book seems to be not very clear. In the appendix the reader will find much practical information; of special interest is the atlas of single-stage experimental data. One can only regret that further information about the testing procedure and experimental facilities was omitted.

M. Horejsi, Czechoslovakia

6239. Meister, E., Flow of an incompressible fluid through an oscillating staggered cascade, *Arch. Rational Mech. Anal.* **6,** 3, 198–230, Nov. 1960.

Author assumes that the flow in a plane stationary cascade can be regarded as a model of the actual flow in the blading passage of a stage with N blades of an axial compressor.

Thus a straight infinite cascade of infinitely thin, plane and infinitely long plates is studied, whose N blades oscillate harmonically and induce an unsteady velocity field, (i.e. a time-dependent field). It is assumed that the direction of the velocity

of the flow, which is unperturbed by the cascade, coincides with the mean direction of the oscillating blade profiles.

The two-dimensional unsteady velocity field in the z-plane is computed as a field of velocities induced by the bound vortices of the blades and the free vortices of the wake, with due consideration of the prescribed boundary conditions of the flow. This computation is reduced to a system of singular integral equations. Kelvin's circulation theorem, with the assumptions which are usual in the linear field theory, is applied to show that the velocity field and the vortex distribution may be regarded as functions of the amplitude of the blade oscillations.

The original system of the integral equations, which comprise distribution of bound vortices in *unsteady* flow, is reduced to a system of integral equations for a complex *steady* velocity field. To find a solution for the latter system, the author uses a conformal mapping of the given cascade (z-plane) to the ζ-plane, in which the blades of cascade may be transformed into a single flat blade profile. For the solution of this boundary problem Hilbert's method is applied.

On the basis of the velocity field computed as above, the lift and the moment of the oscillating blades are computed.

The results of this publication, which is mathematically very interesting, yield such complicated formulas that it will hardly be possible to apply them practically. This is why the author in his paper has not entered into any numerical example.

M. Strscheletsky, Germany

6240. Lieblein, S., and Johnsen, I. A., Resume of transonic-compressor research at NACA Lewis Laboratory, *ASME Trans.* **83** *A (J. Engng. Power)*, 3, 219–234, July 1961.

6241. Aleksandrov, B. K., Hydroelectric stations with horizontal turbines (in Russian), *Gidrotekh. Stroit.* **30**, 6, 1–8, June 1960.

Characteristic data of some Russian horizontal model turbines are compared with the data of vertical ones. The design and hydraulic problems of horizontal turbines are discussed in detail. In author's opinion the discharge of horizontal turbines is 1.4 times greater and their efficiency higher than those of vertical turbines.

A. Verba, Hungary

6242. Nechleba, M., The water flow in spiral casings of hydroturbines (in English), *Acta Techn. Nakladatelstvi Ceskoslovenske Akad.* **5**, 2, 111–123, 1960.

Velocity distribution measurements are reported for the exit of two 180° bends. One of them had a flow diversion similar to that of a spiral casing of a turbine. The other was an ordinary bend. In both cases flow passed through a long straight pipe before arriving at the bend. Pitot tube traverses were made and velocities taken at 45 different points. Velocity distributions showed maxima close to the outer side of the bend. This is contrary to the irrotational flow distribution and is due to the presence of the long pipe upstream of the bend. Author states that the usual turbine design is based on the irrotational velocity distribution, which is approximately correct only when no penstocks are required, as in the case of low head power plants. He also states that model performance will not necessarily be reproduced by prototype unless the penstock length in the model represents that of the prototype.

A. Balloffet, USA

6243. Comolet, R., Contribution to the study of the efficiency of an axial turbomachine for incompressible fluid (in French), Publ. Scient. Tech. Min. Air, France no. 372, 54 pp., 1960.

For a two-dimensional stage of a turboaxial blower, author calculates blade angles for maximum efficiency assuming constant ratio of drag to lift for the blade element. Using this result, a three-dimensional stage is calculated by integration over the radius, again assuming constant drag-lift ratio, constant head and constant axial velocity along the radius. Radial equilibrium is not considered.

L. S. Dzung, Switzerland

6244. Mityushkin, Yu. I., Questions in the theory of the turbine stage with no radial gradient of static pressure in the inter-ring clearance (in Russian), *Izv. Vyssh. Uchebn. Zavedenii: Energetika* no. 10, 80–94, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13385.

The theory of the turbine stage is expounded in the case where the radial gradient of static pressure is small in the inter-ring clearance with a cylindrical or conic flow in the working ring, and also the theory of a turbine stage with a constant thermodynamic degree of reactivity in proportion to the height of the blade when there is a conical flow in the working ring. The customary system of equations for gas dynamics is recorded for an inviscid liquid applicable to the section beyond the working wheel; from these equations a differential equation in particular derivatives is obtained representing the relation of the velocity components to the radius. Two types of a combined turbine stage are investigated: (1) the union of a linearly marked flow in the jet apparatus with a cylindrical flow ($c_r = 0$) in the working wheel; (2) the union of a linear flow in the jet apparatus with a conical flow in the working wheel.

V. Kh. Abiants

Courtesy Referativnyi Zhurnal, USSR

6245. Maki, R. L., and Hickey, D. H., Aerodynamics of a fan-in-fuselage model, NASA TN D-789, 14 pp., May 1961.

The vertical take-off and landing (VTOL) capabilities of airplane with lifting fans mounted in fuselage ducts have been studied in wind-tunnel tests of a large-scale complete model. A high disk-loading fan was mounted in a deep fuselage duct. The unswept wing of aspect ratio 5 was sized to provide a fan-to-wing area ratio of 8 per cent. The test results obtained with the fan-in-fuselage model have been used to determine various methods of accomplishing transition from hover to wing-supported flight. The model characteristics in transition flight illustrate the problems that can be encountered with submerged-fan VTOL airplanes.

Operation of the fan produces large pitching-moment variations with increase in flight speed. The transition flight plan must be selected with care to minimize the required trim and control power. Wing flap deflection will allow the wing to carry a portion of the load at low angles of attack, and aid in reducing the pitching moments. Angle of attack must be varied through transition to provide smooth transition from fan-supported flight to wing-supported flight. Lift-force vectoring (by deflection of duct exit vanes) must be supplemented by some direct thrust during transition flight to eliminate discontinuous attitude and trim changes. The need for variation of several controls to maintain trim through transition suggests that all trim controls should be programmed to a single pilot cockpit control. The control power demands in transition can be reduced by careful duct design.

From authors' summary

6246. Forman, G. W., and Kelly, N. W., Cooling tower fan performance, *ASME Trans.* **83** *A (J. Engng. Power)*, 2, 155–160, Apr. 1961.

Title problem is analyzed using well-known airfoil parameter for the blade element. A simple formula for the fan efficiency is put in a clumsy manner with a number of correction factors. These, and the rule of 3/4 radius as the "average" radius, may be useful sometimes but more often harmful without stating the range of validity.

L. S. Dzung, Switzerland

6247. Heyson, H. H., Tables and charts of the normal component of induced velocity in the lateral plane of a rotor with harmonic azimuthwise vorticity distribution, NASA TN D-809, 200 pp., Apr. 1961.

The time-averaged induced velocities in the lateral plane of a rotor are computed for wake vorticities which vary as harmonics of the azimuth angle. The first six harmonics are treated for two wake skew angles. The calculated results are presented in the form of contour charts and tables. A brief discussion of the computing program, which featured automatic preparation of the contour charts, is also included. From author's summary

6248. Brusilovskii I. V., The selection of parameters for axial ventilators (in Russian), Prom. Aerodinamika no. 10; Moscow, Oborongiz, 1958, 5–35; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13380.

An expression is obtained for the efficiency (k.p.d.) of an axial single-stage ventilator of arbitrary design in terms of the functions of coefficients for the axial velocity and the theoretical pressure, the coefficients for the reciprocal quality constituting the stage of the blade rims, and also the coefficients determining the loading capacity of the fixed blade rims—the directing and rectifying apparatus. Approximate formulas are derived for the optimum values (corresponding to the maximum value for the efficiency, k.p.d.) for the coefficients of axial velocity and curvature of the flow in the directing and rectifying apparatus. An evaluation is given for the drop in efficiency (k.p.d.) when there is any departure from the optimum values for the parameters. Here the assumption is made that the magnitude of the reciprocal aerodynamic quality remains a constant. To meet the case when the reciprocal quality varies with the coefficient of velocity in conformity with the hyperbolic principle a determination is made of the optimum value for the axial velocity and for the maximum efficiency (k.p.d.) which is governed by the variability of the coefficient for the reciprocal quality. The obtained expressions are extended to include the more general cases of multistage ventilators, of ventilators with counter rotation, and also of axial ventilators working in installations subject to different losses. A. S. Ginevskii

Courtesy Referativnyi Zhurnal, USSR

6249. Ushakov, K. A., and Bushel', A. R., Investigation on the influence exercised by the number of blades on the characteristics of an axial ventilator (in Russian), Prom. Aerodinamika no. 10; Moscow, Oborongiz, 1958, 36–42; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13381.

Results are given of the enquiry stated in the title. The blades were of the foliate type; the external diameter of the wheel was 700 mm, the internal 490 mm; the number of blades was equal to 14, 20, 28, 40 and 46. The tests carried out in a chamber equipped with a blower and with a velocity of rotation of 850 revs/min disclosed a sharp deterioration in the work of the wheel when the number of blades was increased; the power is reduced, also the pressure and the efficiency (k.p.d.). This defect is explained in the paper by the change in the angle of opening in an equivalent conical diffuser when the number of blades is varied.

A. S. Ginevskii

Courtesy Referativnyi Zhurnal, USSR

Flow and Flight Test Techniques and Measurements

(See also Revs. 5847, 5867, 6125, 6160, 6263, 6278, 6353, 6426)

6250. Coffin, J., Effect of inclination on current meter response (in French), International Current Meter Group, East Kilbride, Scotland, Report no. 1, 6 pp. Sept. 1960.

Screw-type current meter was tested in an aerodynamic tunnel at different angles of inclination in order to determine change in friction resistance. The friction decreases with the angle. Effect decreases at great velocities. S. Kolupaila, USA

6251. Di Ricco, G., Weirs of polygonal shape (in Italian), Direzione generale del Catasto e Servizi Tecnici. Ministero delle Finanze, Roma **15**, 3, 16 pp. 1960.

The third article on design of a proportional weir to measure water discharge to first power of head, substituting hyperbolic contour by a polygonal within limits of allowable error.

S. Kolupaila, USA

6252. Fukusawa, K., and Iguchi, M., On measurement of small quantity of gas flow by primitive Venturi tube, *J. Mech. Lab. Tokyo* **6**, 1, 1–4, 1960.

Discharge coefficients of various shapes of Venturi tubes which are relatively easy to prepare in a laboratory were determined in a range of low Reynolds numbers. Experiments were not sufficient to give the mutual functional relations between the discharge coefficient and the elements of design. The experimental values of α as a function of Re_d are given by one fixed curve within 4% error.

E. Eujen, Germany

6253. Iwanami, S., Correction factors of the capillary viscosimeter, *Mem. Fac. Technol. Tokyo Metrop. Univ.* no. 10, 728–735, 1960.

Author experimented with the viscous flow through pipes, short tubes, and orifices over a range of Reynolds number. The viscous inlet loss, the viscous exit loss and the kinetic energy change are expressed in terms of correction factors to the Hagen-Poiseuille law. R. C. Binder, USA

6254. Lilly, G. M., and Morton, D., The response time of wind tunnel pressure measuring systems, Coll. Aero., Cranfield, Rep. 141, 20 pp. + figs., Nov. 1960.

Analysis of gas flow in capillary tube connected to tranducer of fixed volume for a step change in the inlet pressure. Report is an extension of paper by Kendall (A.G.A.R.D. Meeting, London, 1958) who assumed friction loss equal to steady state.

Analysis neglects wave effects in tubes so is inaccurate for small times, and some assumptions are more critical than indicated, e.g. in derivation of Eq. [5.13] the product of the radius-length ratio times Reynolds number based on a *reference speed*, $\sqrt{RT}$, is required to be less than unity. Also it is not clear that the square of the pressure is assumed to vary linearly with distance for all time.

Theory agrees tolerably well with experiments except at small and very large times, but the details of the estimated inlet and outlet losses are not given. A more complete treatment is contained in AMR **14**(1961), Rev. 3756.

S. R. Montgomery, England

6255. Bernard, J.-J., Tests of kinetic heating in wind tunnels (in French), *Rech. Aéro.* no. 76, 17–24, May/June 1960.

Author describes methods of measuring rates of kinetic heating on models at high Mach numbers. Preliminary experiments were made in a free jet at $M = 2.7$ preheated to a stagnation temperature of 1000 °K by the combustion of kerosene and were later extended to much higher Mach numbers. Although some experimental results are quoted for heat transfer rates on a backward facing step at $M = 3$, the paper concentrates on a critical review of techniques; the use of infrared comparators and fusion are mentioned but the main discussion is of the thin-pastille technique as developed by Valensi and techniques employing thin-walled models, where the inner wall is assumed to be insulated, and models mounted on a massive core which is supposed isothermal. A useful survey.

P. R. Owen, England

Thermodynamics

(see also Revs. 5884, 6121, 6177, 6196, 6272, 6279, 6289, 6302, 6307, 6309, 6313)

Book—6256. Bahn, G. S., and Zukoski, E. E., edited by, Kinetics, equilibria and performance of high temperature systems (Proceedings of the First Conf., Western States Section, The Combustion Inst., Los Angeles, Calif., Nov. 2–5, 1959), Washington, D. C., Butterworth, Inc., 1960, x + 255 pp. $20.

This volume constitutes the unclassified portion of a meeting held in Los Angeles in November 1959. The purpose of the meeting was to exchange information among those engaged in performance calculations for high-temperature systems in order to minimize duplicative efforts on computer programming and preparing libraries of thermodynamic properties. The policy was established of accepting all offerings describing original work without any attempt to avoid duplication.

As a result of this policy there is a large number of papers (15 out of 33) dealing with the calculation of the equilibrium composition of gas mixtures. Some of these also deal with the further calculation of propellant performance. The other papers deal with such topics as thermodynamic properties, spray combustions, combustion in rocket engines, flow of reactant gases and approximate expressions for the properties of air at high temperatures.

Reviewer believes that interest in this volume will be limited primarily to specialists but that it should be acquired by technical and company libraries. W. Squire, USA

Book—6257. Myerson, A. L., and Harrison, A. C., edited by, Physical chemistry in aerodynamics and space flight (Proceedings of the Conference on Physical Chemistry in Aerodynamics and Space Flight, University of Pennsylvania, Sept. 1–3, 1959), New York, Pergamon Press, 1961, viii + 288 pp.

The advent of space flight has made it important to study physical chemical phenomena at very high temperatures over a wide range of conditions since chemical reactions and other effects neglected in ordinary flow problems are major factors in hypersonic flow. The early investigations of such problems appeared in reports of limited circulation or in the chemical literature with little indication of their relevance to space technology. The purpose of the conference was to provide for an exchange of ideas and information between aerodynamists and physical chemists on the present and future fundamental physical chemical problems of high-speed aerodynamics and space flight.

The volume is divided into four sections, each with a brief introduction by the session chairman. The sections are: Surface and solid phase reactions (12 papers); Gas phase reactions and kinetics (7 papers); Experimental methods and simulation (7 papers); and, Thermodynamic and transport properties of gases (9 papers).

The last section is most directly related to applied mechanics. Reviewer particularly recommends the paper by Brokaw on "Energy transport in high temperature and reacting gases." The paper by Amdur on the calculation of transport properties from measured intermolecular potentials and the description by Treanor and Skinner of a molecular beam utilizing a shock-tube source to obtain temperature between 10^4–10^5K are also of interest. Walker and coworkers describe a method of computing the intermolecular potential from diffusion measurements in the 300–1500°K range.

The first section contains several papers on the processes involved in ablation, a subject which is currently of great interest. A number of papers in the second and third section involve gases behind shock waves.

The typography is exceptionally good but reviewer wonders whether a collection of papers warranted such an effort and the resulting delay. W. Squire, USA

6258. Schenck, H., Frohberg, M. G., and Steinmetz, E., Derivations for the purpose of defining thermodynamic action quantities in multicomponent systems (in German), *Arch. Eisenhüttenw.* **31,** 11, 671–676, Nov. 1960.

Using the method of C. Wagner, the authors derive relations, in terms of several methods of expressing compositions, for the effects of the presence of additional components on the activity coefficient (or activity, or chemical potential) of a solute of a solution dilute in all solutes. Particular attention is given to solubility effects where the activity of one of the solutes is constant, for example, the effect of the addition of tungsten on the solubility of carbon in liquid iron at a constant temperature.

J. A. Beattie, USA

6259. Konowallow, D. D., and Hirschfelder, J. O., Morse potential parameters for O–O, N–N, and N–O interactions, *Physics of Fluids* **4,** 5, 637–642, May 1961.

Morse potential parameters are determined for the atom-atom interactions corresponding to a large number of spectroscopic states having potential minima, for molecular oxygen, molecular nitrogen, and nitric oxide. Some implications concerning unique assignments of dissociation products and dissociations energies, and the possible existence of an unobserved excited state of nitric oxide, are discussed. E. A. Mason, USA

6260. Metenin, V. I., Investigation of vortex temperature type compressed gas separators, *Soviet Phys.–Tech. Phys.* **5,** 9, 1025–1032, Feb. 1961. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **30,** 9, 1095–1103, Sept. 1960 by Amer. Inst. Phys., Inc., New York, N. Y.)

Paper presents experimental data covering the effect of various design factors on the working process of various counter-flow vortex tubes. The results indicated that the best construction for the flow rectifier was of the grid type.

G. A. Hawkins, USA

6261. Sengers, J. V., and Cohen, E. G. D., Statistical mechanical derivation of the generalized Boltzmann equation for a fluid consisting of rigid spherical molecules, *Physica* **27,** 2, 230–244, Feb. 1961.

An analysis is made as to whether the modified Boltzmann equation originally proposed by Enskog with intuitive arguments can be justified by a statistical mechanical derivation. In a preceding paper [Cohen, E. G. D., *Physica* **26,** p. 163, 1960] the theory of Bogolyubov and the theory of Kirkwood as to the derivation of a generalized Boltzmann equation for a dilute gas were compared and it was proved that corrections to the ordinary Boltzmann equation due to the first-order terms of an expansion in terms of a uniformity parameter μ are equal. In the present paper both theories are applied to a dense system of rigid spherical molecules. It is shown that both theories give again a similar equation for the first distribution function, leading under a number of assumptions to the Enskog equation.

In some publications it has been stated that the theory of Kirkwood would lead to an equation for the first distribution function essentially different from the Enskog equation and suggestions have been raised elsewhere that this disparity might be due to the integration procedure applied to the Liouville equation, which would not be legitimate for a discontinuous rigid sphere potential. On the contrary to this the present derivation shows that also in the theory of Kirkwood the Enskog equation can be obtained from the general $(N-1)$ times integrated Liouville equation.

From authors' summary by Y. S. Touloukian, USA

6262. Friauf, J. B., Thermodynamics of thermally regenerated fuel cells, *J. Appl. Phys.* **32,** 4, 616–620, Apr. 1961.

It is shown that $d(\theta\Delta H)/dT = 0$ is a necessary condition for the attainment of Carnot cycle efficiency, $(T_1 - T_2)/T_1$, by a thermally regenerated fuel cell system in which ideal gases are reacted in a fuel cell to convert chemical to electrical energy, and are then regenerated for recycling by thermal dissociation of the product of the reaction, also assumed to be an ideal gas. In $d(\theta\Delta H)/dT$, T is the temperature, ΔH is the change in enthalpy for the reaction in the fuel cell, and θ is the degree of reaction, or the fraction of the road from zero to 100% product which is covered by the reaction when chemical equilibrium is reached. Formulas are given for calculating the theoretical efficiency. Curves show calculated efficiencies for hypothetical thermodynamic data chosen to illustrate the effect of thermodynamic properties on efficiency. Temperature-entropy diagrams are used to explain why the efficiency reaches a maximum and then decreases when T_2 is held constant and T_1 is increased. The efficiency is pressure-independent when the reaction does not involve change in the number of molecules, pressure-dependent when it does.

From author's summary

6263. Sharbaugh, A. H., and Lippitt, M. W., Jr., A capacitance densitometer for determination of the transient densities of cryogenic liquids, *ARS J.* **31,** 3, 294–296, Mar. 1961.

In the operation and testing of rocket engines using liquid propellants, it is desirable to measure continuously the density of the flowing liquid under transient conditions where the changing temperature and pressure cause small, but important, density changes. This report describes a novel method for doing this by measuring the electrical capacitance of a calibrated concentric-cylinder capacitor which is inserted into the feed system of the rocket engine. Test results with liquid oxygen show that this capacitance densitometer will indicate changes in density to about ±0.2% accuracy and absolute values of density may be measured with an error of about ±1%.

From authors' summary

6264. Zucker, I. J., The reduced equation of state of the inert gas solids at the absolute zero, *Proc. Phys. Soc. Lond.* **77,** 496, 889–900, Apr. 1961.

It is shown that a law of corresponding states exists among the inert gases in the solid phase even when quantum effects are large. The theoretical treatment is based on the Einstein model of a crystal modified to account for large vibrations of the crystal atoms. Using a Lennard-Jones 12–6 potential for the interaction energy between a pair of atoms, reasonable agreement is obtained between theoretical and experimental values for the equilibrium volumes and energies of the rare gas crystals at the absolute zero.

From author's summary

6265. Bekarevich, I. L., and Khalatnikov, I. M., Theory of the Kapitza thermal discontinuity of the boundary between liquid He^3 and a solid body, *Soviet Phys.-JETP* **12,** 6, 1187–1195, June 1961. (Translation of *Zh. Eksp. Teor. Fiz., Akad. Nauk SSSR* **39,** 6 (12), 1699–1712, Dec. 1960 by Amer. Inst. Phys., Inc., New York, N. Y.)

The problem of motion in a Fermi liquid due to vibrations of the boundary is treated. The energy transferred to the liquid during thermal vibrations of the solid body and the related heat transfer at various temperatures of the liquid and the solid are computed by applying the resulting solutions. The thermal resistance derived is proportional to T^{-3}.

From authors' summary

Heat and Mass Transfer

(See also Revs. 5831, 5856, 5879, 6104, 6121, 6150, 6188, 6192, 6194, 6197, 6198, 6255, 6257, 6259, 6260, 6265, 6317, 6340, 6365, 6366, 6367, 6394)

6266. Schneeweiss, G., Determination of the temperature field in composite bodies (in German), *Öst. Ingenieur Z.* **4,** 2, 49–57, Feb. 1961.

Paper illustrates a method of applying conformal plotting to obtain the temperature field in a composite body composed of materials with differing conductivities. In effect the distances between the constant heat flow line are varied in each material so that the same quantity of heat flows from one isothermal line to another. Three boundary conditions are considered: (1) the temperature is specified at all points on the boundary; (2) the heat flow is specified at all points on the boundary; and (3) the heat flux is in accordance with Newton's law at all points on the boundary. Five examples of differing complexity are presented.

Reviewer feels the paper is interesting but does not see any advantage of the mapping method over the more usual numerical methods.

W. A. Wolfe, Canada

6267. Tien, C., Approximate solutions of conduction of heat through non-homogeneous medium, *Canadian J. Chem. Engng.* **39,** 1, 42–44, Feb. 1961.

By comparing the respective difference equations of heat conduction through a homogeneous and nonhomogeneous media, an approximate analogy is presented. This analogy yields the solution for conduction in a nonhomogeneous medium in terms of the known solution for the homogeneous case. To illustrate the pertinent details an illustrative example is presented.

L. Lapidus, USA

6268. Makhovikov, V. I., The problem of heat conduction and thermal elasticity for a plane with an infinite number of groups of openings (in Russian), *Inzbener.-Fiz. Zb.* **4,** 1, 82–91, Jan. 1961.

This paper deals with the heat-transfer two-dimensional boundary-value problem for an infinite plane with an infinite number of identical multi-connected groups of round holes, each group having an identical temperature field. An approximate solution is given by reducing the problem to formally independent problems for simply connected regions for each hole. A similar solution is given for the corresponding thermoelastic problem. An estimation of error is also included.

P. P. Teodorescu, Roumania

6269. Tsoi, P. V., Transient heat exchange in a system of bodies (in Russian), *Inzbener.-Fiz. Zb.* **4,** 1, 120–123 (Notes), Jan. 1961.

Two semi-infinite solid bodies have a plane of contact. The conduction of heat in these bodies and across the boundary is studied by means of the familiar differential equation and standard boundary conditions. The distribution of the temperature and the heat flow are obtained by Fourier analysis. Results are simple and correct but there is not much of originality in this paper.

R. Eisenschitz, England

6270. Chu, W. H., and Abramson, H. N., Transient heat conduction in a rod of finite length with variable thermal properties, *ASME Trans.* **82** E (*J. Appl. Mech.*), 4, 617–622, Dec. 1960.

A numerical procedure is developed for solving the differential equation of unidirectional heat conduction with temperature-dependent thermal properties. The equation is transformed into a diffusion equation with concentration-dependent diffusivity, and finite difference methods are employed for solving the latter. Boundary conditions considered are: given temperature or given

heat flux density at the ends of a rod. Truncation and round-off errors are discussed.

An example is given pertaining to a copper bar with given heat flux density at one end and heat insulation at the other end, the thermal diffusivity and conductivity being linear functions of temperature. D. A. De Vries, Netherlands

6271. Aberbanel, S. S., Time dependent temperature distribution in radiating solids, *J. Math. Phys.* **39**, 4, 246–257, Dec. 1960.

Author writes nondimensional equations for one-dimensional transient heat conduction in a semi-infinite solid, a finite slab, a sphere and a spherical shell. Uniform initial temperature and constant thermal properties are assumed. At the surface of these solid bodies, the heat flux varies as a power of absolute temperature (fourth for radiation, 5/4th for natural convection). The effect of back radiation is also considered. Approximate asymptotic solutions are given. The numerical solution for the surface temperature for the semi-infinite solid radiating into a vacuum, as obtained on an IBM 704, is plotted.

A. W. Gessner, USA

6272. Trofimov, E. P., The non-stationary temperature field of an unlimited hollow cylinder (in Russian), *Inzbener.-Fiz. Zb.* **3**, 10, 47–53, Oct. 1960.

Author considers time-varying temperature field in an infinite hollow cylinder subject to prescribed initial temperature distribution and whose inner and outer surface are exposed to two different time-varying heat fluxes. Using finite integral transforms general solution with arbitrary boundary heat fluxes is obtained. Subsequently, by postulating explicit form of boundary conditions, solutions for several special cases are derived.

B. Zarwyn, USA

6273. Lavrentyev, S. A., An approximate solution of the problem of the heating of a cylinder (in Russian), *Inzbener.-Fiz. Zb.* **3**, 7, 135–138, July 1960.

The problem of heating solid and hollow cylinders uniformly by a distributed flow of heat is considered. Author presents simple formulas convenient for determination of temperature in practically important cases (heating of brake disks, surface electric tempering, etc.).

In the case of the solid cylinder, his method is based on appropriate expressions for Bessel's functions; in the case of hollow cylinder, (with sufficiently small thickness) on investigating its segment as a plate with insulated flank sides.

K. Rektorys, Czechoslovakia

6274. Borchers, K.-O., Heat flow across the walls of industrial furnaces (in German), *Arch. Eisenhuttenw.* **31**, 6, 343–350, June 1960.

Paper studies the effects of the thermal capacity of walls of furnaces on the heat flux for prescribed variations in the inner wall temperature during heating and cooling. Only plane slabs are considered. The calculations are based on the nonsteady one-dimensional Fourier equation and on otherwise known results. The aim is to provide graphs and diagrams for speedy calculations, and no attempt is made to extend known analytic results; in fact, only the result for a temperature jump and *ad hoc* calculations by Schmidt's method are employed. The procedures are based on the introduction of the ratio $\sigma = Q/Q_{max}$ of the heat Q contained in the wall for a given temperature distribution to that (Q_{max}) which is required to pass from one steady-state (uniform temperature) to another (linear temperature distribution). The procedure is reasonably successful for the unrealistic case of a uniform slab. When the slab is composed of several layers, the procedure becomes complex; but it is shown that in many cases only the heat capacity of one layer need be taken into account.

Any competent specialist in heat conduction would be in a position to handle the problem without specific reference to the present paper. J. Kestin, USA

6275. Chudnovsky, A. F., Active effects on the upper layer of soil and the influence of this factor on heat behavior (in Russian), *Inzbener.-Fiz. Zb.* **3**, 4, 23–29, Apr. 1960.

Author considers the following one-dimensional heat flow problem: The change of surface temperature of the soil v is periodic with time due to known sinusoidal change of the temperature of the air at a certain height above the surface of the soil. Soil consists of two homogeneous layers with different thermal diffusivities, one of the layers extending down to infinity. The varying temperature field of the soil is calculated in the usual manner as an extention to the temperature field of the air. The temperature field above the soil is obtained by solving, with the above condition, the equation of turbulent heat conduction, $\partial T/\partial t = \partial(k(z)\,\partial T/\partial z)/\partial z$ (T the temperature, t the time and z the distance from the surface of the soil) by using the fact that the function $k(z)$ is experimentally found to be linear. The considerations lead to formulas which enable one to make calculations about the effect of the cultivation upon the heat behavior of the soil.

O. B. Hellman, Finland

6276. Chen, S.-Y., One-dimensional heat conduction with arbitrary heating rate, *J. Aerospace Sci.* **28**, 4, 336–337 (Readers' Forum), Apr. 1961.

Author solves problem by Laplace transforms and gives small and large time solutions in series form. Same problem has been solved since then by integral transform methods (Kaplan and Sonnemann "4th Midwestern Conference on Solid Mechanics" U. of Texas). [AMR **13** (1960), Rev. 1057].

G. Sonnemann, USA

6277. Lowan, A. N., On stability criteria of explicit difference schemes for certain heat conduction problems with uncommon boundary conditions, *Math. Comput.* **15**, 74, 179–185, Apr. 1961.

Stability criteria are derived for the explicit difference schemes appropriate to the following physical systems: (a) heat conduction in a solid in contact with a well-stirred liquid, (b) heat conduction in a slab with radiation to uncommon boundaries, and (c) heat conduction in a cylinder radiating to the inner surface of a thin coaxial cylindrical shell with infinite thermal conductivity, the outer surface of which radiates into a medium at prescribed temperature. Of decided interest are the unusual boundary conditions associated with these heat conduction systems.

L. Lapidus, USA

6278. Donskov, S. V., Heat transfer from a circular cylinder in transverse flow of a granulated solid (sand) (in Russian), *Teploenergetika* no. 10, 65–71, 1958.

The temperature of a granulated solid material is to be raised by passing it over heated cylindrical pipes placed normal to the flow direction. The rate of heat transfer from a single pipe to quartz sand is experimentally determined. Two types of experiment are described. First visual observations of the flow around a pipe were obtained by observation, through a glass wall, of the flow in a rectangular channel. Layers of sand of alternating colors illustrated the flow pattern. A prominent feature of the flow was a triangular prism of sand which formed at the forward stagnation point of the flow around the pipe. A similar triangular region appears at the rear of the pipe.

Quantitative heat-transfer measurements used a calorimeter in which electric heaters boiled water on the inside of a china pipe with thermocouples measuring the outer surface temperature distribution. Heat transfer was measured in this way as a function of

angular distance around the cylinder, velocity of flow, grain size, pipe diameter and width of flow channel. It was found that for cases in which the pipe diameter was small compared with channel width (negligible wall effects) the average temperature rise of the sand could be correlated on the basis of a Nusselt number and Peclet number. L. H. Schindel, USA

6279. Shlikov, U. P., Ganin, E. A., and Demkin, N. B., An investigation into contact heat exchange (in Russian), *Teploenergetika* no. 6, 72–76, June 1960.

Authors investigate the microscopic model of heat-conduction mechanism between two rough plane surfaces contacting each other. Using this model expressions are derived for the change of the heat resistance between those surfaces upon application of pressure.

The resistances to heat transfer between two surfaces is assumed to consist of conduction resistance in protrusions of both surfaces having common contact and of resistance to heat flow in small gas pockets enclosed by both surfaces. Elastic and plastic deformations in surface irregularities upon application of load are considered and their effect on path of flux is calculated. By averaging over-all microscopic irregularities (assumed to be of equal size) the effect of external load on heat resistance between both surfaces is determined.

It is found that the heat resistance drops upon application of load until it reaches some asymptotic value characteristic for a given material and surface finish. Furthermore, it is found that the main contribution stems from deformation of solid protrusions in contact, the deformations of gas pockets contributing less than 20%.

Analytical results are illustrated with several graphs showing dependence of heat-flow resistance between both surfaces as a function of external load. B. Zarwyn, USA

6280. Nikitin, A. T., Temperature distribution in an unbounded hollow cylinder having heat exchange at the boundaries with variable temperature media (in Russian), *Inzbener.-Fiz. Zb.* **3**, 8, 74–77, Aug. 1960.

Author considers heat conduction in a hollow infinite cylinder $r_0 \leqq r \leqq r_1$ with constant initial temperature T_0 and with convection heat exchange on both surfaces:

$$\frac{\partial\theta}{\partial r} + b_0 [f(t) - \theta] = 0 \text{ for } r = r_0, \quad f(t) = T_1(t) - T_0,$$

$$\frac{\partial\theta}{\partial r} - b_1 [\varphi(t) - \theta] = 0 \text{ for } r = r_1, \quad \varphi(t) = T_2(t) - T_0;$$

b_0, b_1 are positive constants, the temperatures $T_1(t)$, $T_2(t)$ arbitrary functions of time.

The problem is solved with the help of the Laplace transform; the construction of the original function is based on the residuum theorem. K. Rektorys, Czechoslovakia

6281. Dusinberre, G. M., A note on the "implicit" method for finite-difference heat-transfer calculations, *ASME Trans.* **83**C (*J. Heat Transfer*), 1, 94–95 (Tech. Briefs), Feb. 1961.

6282. Mochalin, A. I., Heating of a sphere by an instantaneous surface source of heat (in Russian), *Inzbener.-Fiz. Zb.* **4**, 1, 124–126 (Notes), Jan. 1961.

6283. Sellers, J. P., Jr., Effect of two-dimensional heat transfer on wall temperatures in a tubular thrust chamber, *ARS J.* **31**, 3, 445–447 (Tech. Notes), Mar. 1961.

6284. Altshuler, L. M., The temperature field of a cylindrical source in a half-limited block (in Russian), *Inzbener.-Fiz. Zb.* **4**, 3, 64–71, Mar. 1961.

6285. Rosen, E. M., and Scott, E. J., The Leveque solution with a finite wall resistance, *ASME Trans.* **83**C (*J. Heat Transfer*), 1, 98–100 (Tech. Briefs), Feb. 1961.

6286. Schmidt, Th. E., Concerning heat transfer coefficients of heat-insulating materials (in German), *Forsch. Geb. Ing.-Wes.* (*B*) **27**, 1, 10–14, 1961.

Paper classifies basic structure of heat-insulating materials as (1) continuous solid enclosing numerous gas-filled cells of varying size and shape, such as foam materials, (2) fibrous material in a continuous gas-filled space, and (3) pulverized material, which may be considered the negative of (1), in that a continuous gaseous material encloses numerous solid particles of varying size and shape. Over-all heat transfer coefficient is considered to be resultant of coefficients expressing amount of radiation, heat conduction through solid portions, heat transfer by convection, and heat conduction through gas. In general, coefficient is much more affected by number, size, and shape of pores than by total pore volume. Coefficient is expressed in terms of nondimensional quantity which includes effect of particular structure by use of mean pore size (small fraction of millimeter, though individual sizes may vary by orders of magnitude) and distribution. By such studies, including experimental measurements (some included in paper), it is hoped that best structures can be determined and incorporated into practice. C. W. Smith, USA

6287. Norman, W. S., and McIntyre, V., Heat transfer to a liquid film on a vertical surface, *Trans. Inst. Chem. Engrs.* **38**, 6, 301–307, Dec. 1960.

The flow of a liquid film over a vertical surface is changed when heat transfer from the surface into the liquid film occurs. At a large rate of water flow, the film covers the whole surface. When the flow rate is reduced, vertical bands appear in which the film thickness is considerably greater than the average, whereas the areas in between are only covered with a very thin film. With a further reduction of the flow rate, dry patches occur which at first are periodically covered and with further reduction stay permanently dry. Heat transfer from the wall to the liquid film at first increases when the vertical bands appear and then is sharply reduced when the dry patches occur. The minimum liquid rate required to maintain a continuous film can be correlated as a relation between a dimensionless parameter expressing essentially the film thickness and a second parameter containing the surface tension. The relation is similar to one previously derived from work on distillation and gas absorption. Boiling of the liquid at the wall surface causes a marked reduction of the minimum wetting flow rate and a sharp increase in heat-transfer coefficients. The heat-transfer coefficients are of the same order as those measured in nucleate boiling on a submerged surface.

E. R. G. Eckert, USA

6288. Nakamura, K., Nakatani, M., Harada, I., et al., Researches on new heat transmitting tubes: Part 2, On the combination bundles of circular and new finned tubes, *Bull. JSME* **3**, 12, 496–500, Nov. 1960.

This supplements earlier report by Nakamura and others [AMR **13**(1960), Rev. 3046].

The new heat-transmitting tube has two axial fins, each 10 mm high, projecting symmetrically from the upstream face of a plain circular tube 38-mm o.d. The fins are inclined at 40° to each other.

Authors present experimentally determined characteristics of air-to-tube forced-convection heat transfer for combinations of four rows of tubes. In all combinations the tubes are staggered and the pitches are constant at 80 mm. Combinations differ in the number of rows of the new tubes on the upstream side, the remaining rows being of plain circular tubes also 38-mm o.d.

Authors claim that an arrangement of either two rows of new tubes followed by two rows of plain tubes, or one row of new tubes and three rows of plain tubes, has a performance comparable with an arrangement of four rows of new tubes, and better than an array of plain tubes only. Reviewer believes that an array of plain tubes only with reduced pitch should have been used for comparison.

Heat-transfer coefficients for a single new tube and for single tubes with different numbers of circular transverse fins are presented.

All experimental data are obtained for average air velocities in the range 4 to 8 m/sec. T. D. Patten, Scotland

6289. Farzetdinov, M. M., The transmission of heat through a rotating cylindrical body (in Russian), *Inzbener.-Fiz. Zb.* **3**, 9, 117–119, Sept. 1960.

This paper contains further solutions to the title problem formulated in author's previous paper [*Inzbener.-Fiz. Zb.* **2**, 10, p. 82, 1959]. The problem considers rotating infinite cylindrical body enclosed in another solid medium of infinite extent with the boundary conditions stipulating continuity of temperature gradient at infinity.

The solution obtained in the form of Bessel functions describes the radial and transversal components of the temperature waves within the cylinder and the dependence of their amplitude upon the speed of rotation. B. Zarwyn, USA

6290. Picot, J. J. C., Experimental study of heat convection in a channel with variable velocity profile (in French), Publ. Scient. Tech. Min. Air, France no. NT 94, 14 pp., 1960.

Author gives a wide range of measured velocity profiles and heat transfer rates for turbulent flow through a two-dimensional channel of uniform section, the velocity profiles being varied by means of a movable wall.

The results are just what might be expected.

N. Curle, England

6291. Sellers, J. P., Jr., Effect of carbon deposition on heat transfer in a LOX/RP-1 thrust chamber, *ARS J.* **31**, 5, 662–663 (Tech. Notes), May 1961.

6292. Cheers, F., and Liley, J. N., Heat transfer from slotted finned tubes, *Inter. J. Heat Mass Transfer* **2**, 3, 259–261 (Shorter Communication), Apr. 1961.

6293. Mezhirov, I. I., Flow of gas in a canal subject to the presence of heat transfer (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 102–106, Jan./Feb. 1961.

6294. Jackson, T. W., Spurlock, J. M., and Purdy, K. R., Combined free and forced convection in a constant temperature horizontal tube, *AIChE J.* **7**, 1, 38–41, Mar. 1961.

Experiments were carried out on laminar and turbulent flow of air in a horizontal pipe without superposed acoustic waves even though Fig. 1 includes a horn. Correlation of data was made by an interpolating procedure between the case where the fluid is heated nearly to the constant temperature of the tube wall and the case in which free convection forces are unimportant. Results, however, do not compare to those of Martinelli and Boelter because of different entrance conditions for various L/D ratios.

S. L. Soo, USA

6295. Nishikawa, K., Photographic study of saturated free convection stable film boiling, *Bull. JSME* **4**, 13, 115–123, Feb. 1961.

Experimental study of saturated film boiling of water and sodium oleate solutions using immersed nichrome wire as the heating surface. Reasonably good photographs of various phases of bubble formation were obtained. The initial bubble size is several times as great as the diameter of the heated wire. Author obtains data on bubble diameter, frequency of bubble formation and heat-transfer coefficient. The latter agrees with Banchero's earlier results. Paper is of interest in the study of quenching processes.

D. R. F. Harleman, USA

6296. Sorokin, M. P., An experimental investigation of the stability of convection motion of a liquid in a long vertical slit (in Russian), *Inzbener.-Fiz. Zb.* **4**, 2, 106–108, Feb. 1961.

Gershuni has studied theoretically the stability of laminar flow with heat convection in a cavity between vertical boundaries at different temperatures. The stationary motion was characterized by a linear temperature distribution in the flow. A critical Grashof number, which determines when turbulence occurs, is given. Author of this paper examined experimentally the motion studied by Gershuni for a ratio of length of gap to width of 44. The Grashof number at which turbulence occurs was found from the change in the slope of the curve relating the difference of temperature between the plates and the rate of supply of heat to the plate. The experimental data agree well with theoretical results previously given by Gershuni. M. M. Stanisic, USA

6297. Farzetdinov, M. M., Steady natural convection in a circular, horizontal pipe with a harmonically variable cross-section, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **24**, 3, 833–837, 1960. (Pergamon Press, 122 E. 55th St., New York 22, N.Y.)

The method involves a transformation of coordinates (such that the variable cross section becomes circular), followed by a double expansion in powers of the wave amplitude of the cylinder and of the Grashoff number. No results are given.

N. Curle, England

6298. Lemlich, R., and Levy, M. R., The effect of vibration on natural convective mass transfer, *AIChE J.* **7**, 2, 240–242, June 1961.

Small horizontal cylinders subliming to room air were vibrated in a vertical direction at 20 to 118 cycles/sec. Increases of up to 660% in the coefficient of mass transfer were thus obtained. The coefficient increased with both frequency and amplitude, the latter having the more pronounced effect. Results are correlated in terms of the stretched vibrational Reynolds number introduced in an earlier study and compared with the analogous case of natural convective heat transfer. From authors' summary

6299. Sesonske, A., Velocity and temperature distributions about a horizontal cylinder in free convection heat transfer, *AIChE J.* **7**, 2, 352–353, June 1961.

6300. Tanner, C. B., Businger, J. A., and Kuhn, P. M., The economical net radiometer, *J. Geophys. Res.* **65**, 11, 3657–3667, Nov. 1960.

The net infrared and solar radiation (downward minus upward radiation) can be determined with black and white radiometers. These radiometers consist of two flat painted surfaces, one facing upward and the other one downward. These surfaces, which are protected against natural-convection heat losses by transparent polyethylene films, assume temperatures from which the net radiation can be calculated. The authors derive equation for doing this. Measurements of net radiation are useful in studies of the upper atmosphere, for predicting frost and for crop protection.

A. W. Gessner, USA

6301. Nemchinov, I. V., Some nonstationary problems in the transfer of heat by radiation (in Russian), *Z. Prikl. Mekh. Tekh. Fiz.* **1**, 36–57, May/June 1960.

This is a theoretical study of one-dimensional, transient heating and cooling of a gas by thermal radiation. A general discussion of the basic equations is presented and 11 distinct problems are considered and some numerical results are given.

Proceeding from the integrated, over-all solid angles, form of the equation of transfer of thermal radiation and the equations of gas dynamics in the Lagrangian form, the author shows that the system of equations is not entirely hyperbolic, yet possesses a complete system of characteristics. By linearizing the differential equation of radiant heat transfer, analytic solutions are obtained for some problems. In other cases, approximate solutions of the nonlinear equations are obtained. Some problems solved are for stagnant, and some are for moving, gas, and in only one problem did the author consider molecular conduction as a mode of energy transport.

Since the first-order diffusion approximation for thermal radiation is used, instead of the integral representation, the formulations of the problems are, of course, not exact. However, this reviewer considers the paper a welcome addition to the growing literature on heat transfer in thermal radiation absorbing and emitting media.

R. Viskanta, USA

6302. Martorana, S., The heat supply through transparent walls (in Italian), *Termotecnica* **15**, 2, 89–100, Feb. 1961.

Having described those phenomena which are characteristic of solar radiation through transparent walls, a method is explained for evaluating the heat transfer and calculations are made for frequently occurring cases.

From author's summary by M. J. Goglia, USA

6303. Adrianov, V. N., The effect of dissipation in the processes of radiant energy exchange (in Russian), *Teploenergetika* no. 2, 63–66, 1961.

6304. Adrianov, V. N., Certain problems in theory of radiant heat exchange in one-dimensional schemes (in Russian), *Teploenergetika* no. 6, 63–66, June 1960.

6305. Swann, R. T., Effect of thermal radiation from a hot gas layer on heat of ablation, *J. Aerospace Sci.* **28**, 7, 582–583 (Readers' Forum), July 1961.

6306. Hsu, Y.-Y., and Graham, R. W., An analytical and experimental study of the thermal boundary layer and ebullition cycle in nucleate boiling, NASA TN D-594, 43 pp., May 1961.

The ebullition cycle of nucleate pool boiling from a heating strip was studied through the use of high-speed motion pictures of schlieren and shadowgraph images. The effects of bubble agitation on thermal layer and neighboring bubbles were observed. An over-all model of ebullition based upon experimental observation is proposed that includes an analytical method for predicting bubble growth rate and an analysis of the factors that influence the magnitude of the waiting period (time interval between bubbles at a particular site). Thermal-layer thickness, cavity size, and area of influence of a growing bubble are considered. A film supplement is available.

From authors' summary by J. R. Baron, USA

6307. Labuntsov, D. A., Heat transfer during condensation of steam on a vertical surface in conditions of turbulent flow of a condensate film (in Russian), *Inzhener.-Fiz. Zh.* **3**, 8, 3–12, Aug. 1960.

Author generalizes Nusselt's method for laminar condensation to the turbulent case by incorporating the coefficient of turbulent diffusivity. He uses semiempirical dimensionless relations available in literature for the distribution of that coefficient across the boundary layer. Subsequently, he integrates Nusselt equations with above modifications in a seminumerical fashion and obtains explicit expressions for the local and mean heat-transfer coefficients. Criteria are discussed for the applicability of these expressions to both laminar and turbulent regions of condensation.

As expected, the theory predicts higher heat transfer in the turbulent region of condensation. Graphs are constructed for heat-transfer coefficients during the condensation of water vapor. Also the verification of the derived heat-transfer expressions by experimental data appears satisfactory.

B. Zarwyn, USA

6308. Bowman, C. W., Ward, D. M., Johnson, A. I., and Trass, O., Mass transfer from fluid and solid spheres at low Reynolds numbers, *Canadian J. Chem. Engng.* **39**, 1, 9–13, Feb. 1961.

Theoretical study was made on the effect of internal circulation on the rate of mass transfer from fluid spheres. At Peclet numbers below 10^{-2}, the result is the same as solid spheres and the Sherwood number is 2. At high Peclet numbers, significant increase of mass transfer rate over that of a solid sphere (3-fold at Peclet number of 10^4) is expected. It should be noted that at high Peclet number, the proximity of a gas bubble to spherical shape depends on the surface tension of the liquid. However, approximation by spherical shape should give conservative results in mass transfer because of increased surface to volume ratio as a bubble is distorted.

S. L. Soo, USA

6309. Benzler, H., Contribution to the thermodynamics of nuclear reactor cooling channels (in German), *Forsch. Geb. Ing.-Wes. (B)* **27**, 1, 14–16, 1961.

Paper is fourth of series published by author on general subject of reactor cooling. If area of channel and shape of fuel element remain constant, heat-transfer coefficient and specific heat are approximately constant along channel, but this results in unnecessary pressure loss. For maximum output, passages should be dimensioned for maximum possible heat rejection with highest possible temperature of cooling medium without exceeding permissible pressure loss and fuel element temperature, based on given distribution of heat generation. Paper develops formula to achieve this result, expressed in terms of nondimensional quantity which is constant for constant passage area and fuel element shape, but should be variable for optimum design. Two numerical examples are worked out, one for constant flow velocity and variation of cooling ribs; the other, for a cooling passage of variable area. For these examples pressure losses are about 59% and 44%, respectively, of "normal" losses. Paper is short, easily readable, and although no experimental verification is included, nor are possible mechanical difficulties of construction taken into account, it contains ideas worthy of consideration.

C. W. Smith, USA

6310. Starczewski, J., Graphical design of tubular heat exchangers, *Engineer, Lond.* **211**, 5479, 116–117, Jan. 1961.

Log-log representations of pressure-drop and heat-transfer relationships are given in graphical form which reduce time required to solve equations. Reviewer believes that usefulness of this graphical computing device will depend on taste of designer and accuracy required. Designers who follow trial-and-error method, as outlined in "Process heat transfer" by Kern, will find nomographs of Starczewski helpful since paper is based on procedures of Kern. Reviewer feels that design procedure can be simplified by using direct solutions given in Chapter 15, "Applications to design" of McAdams' text *Heat Transmission—Third Edition.*

D. Aronson, USA

6311. Binder, J. A., Determination of optimal air preheating in ship boilers (in German), *Schiff/stechnik* **8**, 41, 79–86, Apr. 1961.

6312. Abeles, B., Cody, G. D., and Beers, D. S., Apparatus for the measurement of the thermal diffusivity of solids at high temperatures, *J. Appl. Phys.* **31**, 9, 1585–1592, Sept. 1960.

An improvement of Angstrom's method of measuring thermal diffusivities of solids is described. In this method, a thermal wave is propagated through the solid and the thermal diffusivity is determined from the dispersion and attenuation of the wave. The theory which is presented demonstrates that for a cylindrical rod, the thermal diffusivity can be obtained by the relation $D = \omega/2ab$. D denotes the thermal diffusivity, ω the angular velocity, a the phase shift, and b the logarithmic attenuation per unit length of the thermal wave. This relation is based on the assumption that the wave in the interior of the rod is, with good approximation, sinusoidal, that heat is lost from the cylindrical surface by radiation under the condition that the temperature difference between rod surface and the surroundings is small compared to the surface temperature and that the emissivity of the surface is constant. The quantities a and b can be determined by measuring the phases and amplitudes of the temperature waves at two points on the rod. The apparatus developed according to the theory is described. It generates a sinusoidal heat input to one base surface of the cylindrical sample. The frequency of the waves is 1 to 30 cycles/min. The sample with radiation shields is located in a container which is evacuated to a pressure of approximately 10^{-6} mm Hg. Measurements can be performed from room temperature to about 1000°C with an accuracy of approximately 2%. The sample length can vary from ½ to 2 inches. Test results are presented for Armco iron, and for germanium.

E. R. G. Eckert, USA

6313. Simon, R., Bate, R. T., and Laugher, E. H., Measurement of thermal conductivity by utilization of the Peltier effect: Part 2, Correction for wire radiation and determination of specimen radiation emissivity, *J. Appl. Phys.* **31**, 12, 2160–2164, Dec. 1960.

The analysis in the first article on measurement of thermal conductivity by utilization of the Peltier effect [T. C. Harman, J. H. Cahn, and M. J. Logan, *J. Appl. Phys.* **30**, p. 1351, 1959; AMR **13** (1960), Rev. 2504] is extended to correct for radiation of heat from the lead wires. It is shown how the radiation emissivity of the semiconductor specimen can also be determined from the measured temperatures.

From authors' summary by M. J. Goglia, USA

Combustion

(See also Revs. 6256, 6259, 6372)

6314. Raezer, S. D., The relationship between burning velocity and space velocity of a spherical combustion wave in a closed spherical chamber, *Combustion and Flame* **5**, 1, 77–80, Mar. 1961.

Author's analysis yields an expression similar to those of Fiock et al and Lewis and von Elbe. To use Fiock et al expression one needs to know the instantaneous pressure and flame diameter in the bomb. However, only the pressure trace is necessary for Lewis and von Elbe equation, while the present formula requires the record of flame diameter. Since this is usually estimated from photographs the reviewer feels that Lewis and von Elbe expression will give a more accurate result. Unfortunately, no comparison or experimental data are presented. Certainly this would have been of interest. P. R. Choudhury, USA

6315. Osborn, J. R., and Bonnell, J. M., Importance of combustion chamber geometry in high frequency oscillations in rocket motors, *ARS J.* **31**, 4, 482–486, Apr. 1961.

Cylindrical rocket motors were operated with premixed methane-air and ethylene-air. Regions of instability and amplitude of oscillation were measured as functions of chamber pressure, motor diameter, motor length, and fuel-air ratio. Changes in all these variables had profound effects on the transverse oscillations, which interact with the longitudinal mode when the motor is sufficiently long. Authors conclude that the mechanisms causing the longitudinal and transverse modes are similar.

R. Friedman, USA

6316. Watermeier, L. A., Experimental study of combustion instability in solid rocket propellants, *ARS J.* **31**, 4, 564–566 (Tech. Notes), Apr. 1961.

Motion pictures were obtained of double-base propellant specimens burning in the presence of a siren-generated acoustic field of frequency from 100 to 1400 cps. The upper part of this range corresponded to the resonant frequency of the chamber; under these conditions, pressure variations amounting to 20–25% of chamber pressure occurred (but only if combustion was occurring) and substantial increases in burning rate took place. Author believes his observations lend some support to the Hart-McClure theory of acoustic interaction with the burning surface.

R. Friedman, USA

6317. Eulner, R., Mertens, J., and Potter, R. L., Thermal radiation from fluorine-ammonia flames, *Combustion and Flame* **5**, 1, 1–5, Mar. 1961.

The emissivities of stoichiometric NH_3–F_2 flames at atmospheric pressure and two optical lengths have been experimentally determined. Considering the uncertainties of measurements and the values of thermodynamic data, the authors estimate a ±10% reliability of the tabulated emissivities. From these values an average absorption coefficient of the fundamental overtone and the effective charge of HF have been calculated. The present value of the effective charge differs by about 8% from that given previously by Penner. Since the old value was obtained by extrapolation, the new value, according to the authors, appears to be more accurate. P. R. Choudhury, USA

Prime Movers and Propulsion Devices

(See also Revs. 6315, 6316)

Book—6318. Hawthorne, W. R., and Olson, W. T., edited by, Design and performance of gas turbine power plants (High speed aerodynamics and jet propulsion, Vol. 11), Princeton, New Jersey, Princeton Univ. Press, 1960, xiii + 563 pp. $15.

Short historical background is followed by thorough analysis of design requirements of engine and combustion chamber. Subsequent sections are presented by specialists. Experimental techniques for measuring pertinent parameters are authoritatively presented by Hottel and Williams. Mechanics and systems of fuel injection are well presented by Radcliffe. Mechanics of flame stabilization is covered thermodynamically and aerodynamically by Childs. Graves and Scull apply the theory of Prandtl, von Karman, Reichardt and others, along with experimental data, to the problems of momentum transfer, diffusion and mixing of jets, with and without heat, in the burner. Gibbons analyzes the operation and performance of various type fuels in the system and

burner. Olson presents the development of burner configurations. Orowan and Soderberg cover creep, fatigue and other pertinent mechanics of materials for turbines. Schnittger presents several methods of analyzing blade flutter, with discussions on how well they apply. The section on basic thermodynamic, nondimensional parameters, equilibrium running and over-all performance by Mallison and Moyes is short and would need to be supplemented by a thorough text on those areas.

References are generally ample, experimental data good and coverage thorough except as noted. Book could well serve as a text or reference for design of gas turbines, following thorough courses in thermodynamics and turbine performance.

A. S. Andes, USA

6319. Elistratov, F. M., Some special features of gas turbines for installations equipped with free-piston actuated gas generators (in Russian), *Sudostroenie* no. 11, 70–74, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13392.

The matter referred to in the title is investigated (the installation in question being SPGG free piston gas generators) and a description is given of several turbines of foreign make. As examples examinations were made of a 5-stage gas turbine of 6000 H.P. built by the English firm Brash, of a 6-stage turbine of 2000 H.P. made by the German Hamburger Turbinenfabrik, and of some others. Gas turbines for installations with (SPGG) only serve as a source of power for the consumer, therefore they are simple, not large and work with small drops of pressure and a low temperature at the inlet. Small pressure of the gas at the inlet to the turbine enables large volumetric inputs of gas to be obtained and therefore a higher efficiency (k.p.d.—of the order of 85–90%) than in steam turbines. In order to improve the economy of working the turbine at low loads it appears to be expedient to cut off a part of the gas generators working for the turbine in general. The control of turbines in installations with (SPGG) can be effected either by alterations in the feed of fuel to the gas generator or by by-passing part of the gas past the working stages of the turbine to the outlet gas conduit. In marine installations with reverse gear turbines this is carried out on the principle of "countergas" by changing the delivery of gas to the stage of "ahead" or "astern" motion. Going astern in marine installations with (SPGG) is most commonly effected by the use of a turbine with reverse gear, the stages of which are assembled on one rotor with the stages of a turbine with forward gear. In order to reduce the large ventilation losses in a turbine with reverse gear use is made of a meticulously shielded wheel of this turbine by means of a fixed or movable shield which closes the turbine with reverse gear efficiently on the outlet chamber-side. Data are furnished for the economy of working, obtained during tests on some turbines of foreign manufacture intended for use with installations with (SPGG).

V. Kh. Abiants

Courtesy Referativnyi Zhurnal, USSR

6320. Jung, I., Heat utilization from exhaust gas and cooling water in diesel power plants (in German), Jahrbuch Schiffbautech. Gesellsch. **53**, 284–298, 1959.

By recovering waste heat from the exhaust gases of diesel engines, it is possible through a steam-turbine cycle to generate electrical energy mounting to 3.5–6.7% of the engine shaft horsepower. On many types of diesel-driven ships, this is more than enough to drive all electrical equipment when the main engine operates at normal speed. A stand-by diesel generator is needed to supply electric power when the main engine runs at reduced speed. Low-temperature heat (50–60°C) used by air-conditioning equipment and fuel tank heaters can be extracted from the cooling water circulating through the engine jacket. This heat recovery scheme offers considerable savings in investment and operating cost compared to the conventional system in which electric power is generated in a separate diesel generator (usually with two spares), heat for air-conditioners and fuel tank heaters is generated in a fuel oil-fired boiler, and the heat removed from the engine cooling water is rejected to sea water.

A. W. Gessner, USA

6321. Girardin, P., and Tesson, F., Secondary effects of the jet of a jet engine (in French), Publ. Scient. Tech. Min. Air, France no. 373, 61 pp., 1960.

Equations of motion for systems of varying mass are discussed in detail and applied to rocket- and ramjet-propelled bodies for illustration.

First part of paper develops simple theory for special conditions and restrictive assumptions. Control surface enclosing system considered comprises external surface of thrust generator and is of fixed shape. Fuel flow and jet flow are one-dimensional in frame of reference fixed to thrust generator, which consists of slender body of revolution, rotating about an axis of fixed orientation, normal to the body's axis of symmetry. For the exhaust jet, the simplified theory predicts a damping effect, and for the intake flow a destabilizing effect. Similar relations are established in second part of paper, where restrictive assumptions are removed and generalized theory is developed, applicable to system defined by control surface of arbitrarily varying shape. Review of related papers is presented in appendix.

J. V. Foa, USA

6322. Shchukin, V. A., Boosting a turbojet motor by compressing the air in front of the compressor (in Russian), *Izv. Vyssh. Uchebn. Zavedenii: Aviats. Tekhn.* no. 4, 92–100, 1958; *Ref. Zh. Mekh.* no. 11, Rev. 13400.

The system of boosting a turbojet motor by means of jet compression of the air in front of the compressor results in an increase in the total degree of compression of the air and consumption of gas through the motor and, consequently, in an increase in the tractive power. An analytical evaluation is given of the pull developed by a turbojet motor boosted by jet compression of the air in front of the compressor. The calculations were carried out on the basis of the experimental characteristics of jet compressors with an external feed of active air. The influence is examined of the different parameters of active and passive flows of air on the pull and the economy of working of a turbojet motor when being boosted. It was shown that the incremental increase in the pull is greater with increase in the consumption of active air and with a higher assigned velocity in the air, and with a higher assigned velocity in the air intake when the motor is working without boosting. The basic parameters of the motor exercise practically no influence on the increase of the pull and on the change of specific consumption of fuel when boosting is in operation. Results of the calculations showed that when the value of the relation of the temperature of mixing of the passive and active flows of air θ is equal to unity, the increase in the pull of the motor, boosted by jet compression of the air in front of the compressor, is barely distinguishable from the pull obtained by the flow of active air from balloons directly into the atmosphere. However, with $\theta > 1$ this difference becomes very apparent. A calculation was made of the weight of active air and the volume of the balloons required for its storage in relation to the duration of the boosting; analysis of the results obtained showed that the system of boosting turbojet motors being investigated can not be fitted into the space available on an airplane because of the large amount of air that has to be stored. The system of boosting described to increase

the pull of a turbojet motor can only be used when "starting up" on an airfield, with the air containers placed on a truck.

O. V. Yakovlevskii
Courtesy Referativnyi Zhurnal, USSR

6323. Henry, I. G., Relative effects of propellent density and of specific impulse on rocket performance, *J. Brit. Interplanetary Soc.* **17,** 10, 366–371, July/Aug. 1960.

The relative importance of propellant density and of propellant specific impulse is analyzed for three different design situations, namely: (1) propellant volume and part of empty mass fixed; (2) full mass and part of empty mass fixed; (3) full mass and part of empty mass fixed, variable diameter. In all cases assumption is made that rocket accelerates to high burnout speed, then coasts ballistically or aerodynamically. In the first two cases the objective was to maximize the rocket burnout speed, and in the third case to maximize the glide range. In each case a simple effectiveness factor is developed in terms of the rocket component masses. From these relationships the optimum propellant mixture ratios for any case can be determined. A number of illustrative curves are given. F. L. Wattendorf, USA

6324. Stone, M. W., Slotted tube grain design, *ARS J.* **31,** 2, 223–228, Feb. 1961.

Paper presents calculations of geometry of internal burning, slotted circular cylindrical solid propellant charges, and presents results in such a way as to facilitate calculation of rocket motor pressure-time histories and selection of charge designs.

E. W. Price, USA

Book—6325. Corliss, W. R., Propulsion systems for space flight, New York, McGraw-Hill Book Co., 1960, ix + 300 pp. $10.

An extremely broad introductory engineering survey of the fields of space propulsion and space power. Book is strongly recommended for the systems engineer who wishes to be familiar with the whole field without considering finer details which might be of importance to the physicist.

Main chapters are: propulsion-system performance and space missions; environment; power generation; thermal, electrical, and photonic propulsion systems; nuclear-particle generators.

Summary tables and graphs aid the preliminary designer in making comparisons, evaluations, and quick selections regarding the system which will be suitable for a given mission. These tables include information regarding the state-of-the-art, major advantages and disadvantages, applicability; the graphs show performance limits in terms of thrust-to-weight ratio, specific impulse, etc.

Depth is sacrificed somewhat for completeness, preciseness for easy interpretation, physical details for engineering applications, and thorough analysis for summary type presentation.

This is an excellent and unique introductory treatment of a subject with rapidly increasing importance.

V. G. Szebehely, USA

6326. Burry, R. V., Jortner, J., and Rosemary, J. K., High energy propellant comparisons for space missions, *ARS J.* **31,** 5, 609–612, May 1961.

Consideration is given to the thermal insulation requirements of vehicles exposed for extended periods to the solar space environment. Heat flow paths pertaining to typical bipropellant liquid propulsion systems are indicated. A mission is postulated wherein a missile stage, boosted from Earth into a space trajectory, is expected to provide a velocity increment at the end of a coast period. A comparison of several high energy propellant combinations is made in terms of payload capability in the mission. The coast period is varied between zero and ten years in order to discover its influence on the payload comparisons. Results show that the specific propulsion systems considered can sustain coast periods up to 15,000 hr (about 2 yr) without significant change in the payload magnitudes. From authors' summary

6327. Doebler, R. L., Simple method for estimating first-stage boost thrust and specific impulse, *ARS J.* **31,** 4, 550–551 (Tech. Notes), Apr. 1961.

6328. McClure, F. T., Hart, R. W., and Bird, J. F., Heat release rate, temperature and pressure in solid rocket instability, *ARS J.* **31,** 3, 367–368 (Tech. Notes), Mar. 1961.

6329. Frick, C. W., and Strand, T., Recoverable air-breathing boosters—analysis of their potentialities, *Aero/Space Engng.* **20,** 2, 22–23, 66–70, Feb. 1961.

6330. Hatch, L. P., Regan W. H., and Powell, J. R., Fluidized solids as a nuclear fuel for rocket propulsion, *ARS J.* **31,** 4, 547–548 (Tech. Notes), Apr. 1961.

6331. Slocum, R. W., Jr., and Zappala, A. G., Microwave rocket propulsion, *ARS J.* **31,** 5, 651–658 (Tech. Notes), May 1961.

6332. Hayes, R., Seitz, R. N., and Stuhlinger, E., The U.S. ion propulsion program, *Astronautics* **6,** 1, 30–33, Jan. 1961.

Magneto-fluid-dynamics

(See also Revs. 6355, 6370)

6333. Uflyand, Ya. S., Flow stability of a conducting fluid in a rectangular channel in a transverse magnetic field, *Soviet Phys.-Tech. Phys.* **5,** 10, 1191–1193 (Brief Communications), Apr. 1961. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **30,** 10, 1256–1258, Oct. 1960 by Amer. Inst. Phys., Inc., New York, N. Y.)

6334. Levitin, L. B., and Stanyukovich, K. P., The linear approximation to velocity in the problem of the one-dimensional motion of a plasma with finite conductivity, *Soviet Phys.-Doklady* **5,** 5, 948–951, Mar./Apr. 1961. (Translation of *Doklady Akad. Nauk SSSR (N. S.)* **134,** 2, 300–303, Sept. 1960 by Amer. Inst. Phys., Inc., New York, N. Y.)

6335. Yukubenko, A. E., Stationary flow of viscous incompressible conducting fluid in a tube with uniform and nonuniform magnetic fields (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 90–95, Jan./Feb. 1961.

6336. Lighthill, M. J., Note on waves through gases at pressures small compared with the magnetic pressure, with applications to upper-atmosphere aerodynamics, *J. Fluid Mech.* **9,** 3, 465–472, Nov. 1960.

The case is considered in which sound velocity a_0 is small compared with the Alfvén velocity a_1. Except for two modes with wave velocity a_1, the only possible waves are longitudinal, propagated unidirectionally along lines of magnetic force with velocity a_0. These can be interpreted as sound waves. An application is made to the flow pattern around a body moving through the F_2 layer of the ionosphere, where charged particles may be regarded as forming a continuous fluid whose motion is independent of that of neutral particles. A body moving at satellite speed or below would excite the above-mentioned unidirectional sound waves, but no waves at much faster a_1. It is suggested that its movement would

be accompanied by a V-shaped pattern of electron density, which might be in part responsible for some anomalous radar echoes.

From author's summary by R. Nardini, Italy

6337. Polovin, R. V., Flow of a plasma into vacuum in the presence of a magnetic field, *Soviet Phys.-JETP* **12,** 3, 461–463, Mar. 1961. (Translation of *Zh. Eksp. Teor. Fiz., SSSR* **39,** 3 (9), 657–661, Sept. 1960 by Amer. Inst. Phys., Inc., New York, N. Y.)

Hydromagnetic waves excited by disintegration of the boundary between the plasma and vacuum are investigated. The boundary velocity (escape velocity) is determined. The amplitude of the electromagnetic wave radiated into the vacuum during the disintegration of the discontinuity is determined.

From author's summary

6338. Saltanov, N. V., and Tkalich, V. S., Magnetohydrodynamic waves of finite amplitude, *Soviet Phys.-Tech. Phys.* **5,** 10, 1188–1190 (Brief Communications), Apr. 1961. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **30,** 10, 1253–1255, Oct. 1960 by Amer. Inst. Phys., Inc., New York, N. Y.)

6339. Kaul, C. N., On singular surfaces in hydromagnetics, *Appl. Scient. Res. (A)* **9,** 6, 437–449, 1960.

Singular surfaces of first and second order have been investigated in hydromagnetics for which the fluid is assumed to be incompressible, inviscid, non-heat-conducting and of infinitely electrical conductivity. There are two types of singular surfaces: Alfvén waves and contact type of discontinuity. The singular surfaces of the first and second order are similar.

S. I. Pai, USA

6340. Reeves, B. L., Similar solutions of the free convection boundary layer equations for an electrically conducting fluid, *ARS J.* **31,** 4, 557–558 (Tech. Notes), Apr. 1961.

Author investigates the existence of a class of similar solutions for free convection from a vertical flat plate, such as are known for free convection in a nonconducting fluid. The magnetic field acts transversely to the fluid motion and is assumed to remain constant in the direction perpendicular to the plate. This introduces into the momentum equation a retarding force which is a function only of x, the distance along the plate length. For similarity it is found that the magnetic inductance must vary as $1/x^n$. If $n = 1/4$, the plate temperature is constant. If $n = 0$, the magnetic inductance is constant while the plate temperature increases linearly with x.

R. Siegel, USA

6341. Korobeinikov, V. P., and Riazanov, E. V., Some solutions of the equations of one-dimensional magnetohydrodynamics and their application to problems of shock wave propagation, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **24,** 1, 144–158, 1960. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Authors discuss one-dimensional motion, with cylindrical or plane symmetry, of an electrically conducting and perfect fluid in a magnetic field perpendicular to the flow velocity. The velocity is assumed to have only r-component and all functions characterizing the motion are assumed to depend only on r and t.

They point out cases of integrability of the equations of motion and obtain some solutions for various cases. For steady motions of the fluid with infinite electric conductivity, a general solution of the equations is found and, as an example of the solution, the problem of a strong explosion along a plane is considered. For unsteady motions, self-similar solution is obtained for the flow caused by the motion of a piston in a quiescent gas subject to the law $U = A_1 t^n$. Another class of non-self-similar solutions for which the velocity depends linearly on r is obtained, together with the applications to the problem of the motion of gas being compressed by a piston and to that of an impulsive gaseous discharge.

S. Tomotika, Japan

6342. Glauert, M. B., A study of the magnetohydrodynamic boundary layer on a flat plate, *J. Fluid Mech.* **10,** 2, 276–288, Mar. 1961.

Paper treats boundary layer on a semi-infinite flat plate in a uniform stream of conducting fluid, with an aligned magnetic field such that the Alfvén speed is considerably less than the undisturbed fluid speed. Series solutions of the full (nonlinear) boundary-layer equations are derived for cases of large and small values of the electrical conductivity σ. These solutions appear valid for magnetic Prandtl number $\epsilon > 10$ and < 0.001. Here ϵ is equal to $\sigma\mu\nu$ where μ is the magnetic permeability and ν the kinematic viscosity. By comparing the results to solutions obtained for infinite and zero values of ϵ, the approximate range of validity of the latter solutions is obtained. Author indicates that for large but finite ϵ the present solutions are in better agreement with the exact solutions than are those obtained by Oseen linearization techniques used by Greenspan and Carrier [AMR **13**(1960), Rev. 3106].

Reviewer believes this to be a valuable paper in that it points up the degree of error inherent in some of the common assumptions made in MHD theory.

A. L. Loeffler, Jr., USA

6343. Greenspan, H. P., On longitudinal motion in a magnetic field, *J. Fluid Mech.* **9,** 3, 455–464, Nov. 1960.

In an unbounded viscous conducting fluid a rigid semi-infinite nonconducting plate is moved longitudinally with constant velocity in an obliquely incident uniform applied magnetic field. An exact solution of the equations and boundary conditions is presented in terms of elementary known functions. The discussion covers the distorsion of the boundary layer, the structure of the induced electric and magnetic fields, the current-density distribution and the behavior of the fields near the edge of the plate.

From author's summary by R. Nardini, Italy

6344. Chang, I-D., Stokes flow of a conducting fluid past an axially symmetric body in the presence of a uniform magnetic field, *J. Fluid Mech.* **9,** 3, 473–477, Nov. 1960.

Low Reynolds number flow of an incompressible fluid is studied using a perturbation method. It is found that for small Hartmann number M an approximate drag on the body described in title is given by the formula

$$D' = D'_0 \left(1 + \frac{D'_0}{16\pi\rho\nu a U} M \right) + O(M^2),$$

where D'_0 is the Stokes drag for flow with no magnetic effect, ρ is density, ν is kinematic viscosity, a is characteristic length of body, U is the free-stream velocity.

From author's summary by R. Nardini, Italy

6345. Kogan, M. N., Plane flows of an ideal gas with infinite electrical conductivity, in a magnetic field not parallel to the flow velocity, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **24,** 1, 129–143, 1960. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Author previously dealt with plane flows of an ideal gas with infinite electric conductivity when a magnetic field is parallel to the flow velocity. In this paper he discusses, on the basis of the linear theory, the case when a magnetic field is not parallel to the flow velocity.

First, he classifies the flows by the characteristics of the system of basic equations, showing that one elliptic-hyperbolic and two hyperbolic regimes occur in the α-M diagram, where α is the

angle of inclination of magnetic field to the flow velocity and M is the Mach number. It is shown that in the elliptic-hyperbolic regime there are two characteristics, while in the hyperbolic ones there are four.

Author next examines the flows in the hyperbolic regime in case when $H_0 \perp V_0$. In flow past corners in this regime the turning of the flow occurs successively through two compression shocks or two expansion waves. He also discusses the flow around a body containing electric currents perpendicular to the plane of the flow. In a simple example of a flat plate at zero angle of attack, it is shown that flow goes successively through a shock wave and an expansion wave or in the reverse way. In such a flow the perturbations induced by the currents are in general not shielded by the flow, but there appears a magnetic boundary layer around the plate when the transverse magnetic field is vanishingly small.

Further, author examines the flows in the elliptic-hyperbolic regime also in case when $H_0 \perp V_0$ and shows that the general solution for the flows may be decomposed into an elliptic part which dies out at infinity and a hyperbolic part which does not.

S. Tomotika, Japan

6346. Sirotina, E. P., and Syrovat-Skii, S. I., Structure of low intensity shock waves in magnetohydrodynamics, *Soviet Phys.-JETP* **12,** 3, 521-526, Mar. 1961. (Translation of *Zh. Eksp. Teor. Fiz., USSR* **39,** 3 (9), 746-753, Sept. 1960 by Amer. Inst. Phys., Inc., New York, N. Y.)

A general expression has been deduced for the width of low intensity shock waves in magnetohydrodynamics. The damping coefficient for small amplitude waves is determined and its relation to the discontinuity width is established.

From authors' summary

6347. Novikov, E. A., The magnetohydrodynamics of the ionosphere, *Bull. Acad. Sci., USSR, Geophys. Ser.* no. 11, 1085-1090, Nov. 1960. (Translation of *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 11, 1624-1634, Nov. 1960 by Amer. Geophys. Union, Washington 5, D. C.)

A system of magnetohydrodynamic equations for the ionosphere is obtained which takes into account conductivity anisotropies in an approximately irrotational electric field. The electromagnetic fields, the currents, the polarized charges, the electromagnetic force, and the electromagnetic dissipation of energy which accompany the turbulent motion of gas in the ionosphere are investigated spectrally. Effective conductivity coefficients are introduced, characterizing the turbulent flow of the anisotropically conducting gas. An estimate is made of the influence of the earth's magnetic field on the turbulent motion in various layers of the ionosphere.

From author's summary

Aeroelasticity

(See also Revs. 6163, 6164)

6348. Movchan, A. A., The behavior of complex eigenvalues in the problem of panel flutter (in Russian), *Inzhener. Sbornik Akad. Nauk SSSR* **27,** 70-76, 1960.

This is the third in a series of excellent papers on flutter of flat rectangular panels with in-plane loads. In the first two, calculations were confined to conditions for which the eigenvalues have small or zero imaginary part. Results were thus limited to the case of negligible aerodynamic damping. To extend the results to cases of large damping, the present paper presents calculated complex eigenvalues of a panel clamped on the leading and trailing edges and simply supported on the other two for various values of two parameters defining air flow and in-plane loading. These solutions were obtained from the characteristic equation by Newton's method of iteration. Author notes that, for panels compressed to near buckling, flutter can begin, then cease and recur again as the flow velocity is increased. Results presented are cited as typical also of a panel simply supported all around. Preceding papers should be read to understand this one; translations are available (NASA RE 11-22-58W, NASA RE 11-21-58W).

R. W. Leonard, USA

6349. Lamper, R. E., Application of certain aerodynamic theories to the analysis of panel flutter (in Russian), *Zh. Prikl. Mekh. Tekh. Fiz.* **2,** 147-149, 1960.

6350. Stepanov, R. D., Flutter of cylindrical panels moving in a gas (in Russian), *Inzhener. Sbornik Akad. Nauk SSSR* **25,** 92-100, 1959.

6351. Makhortykh, Zh. K., Stability of a multi-span panel moving in a gas (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 2, 174-177, 1959.

6352. Stark, V. J. E., Aerodynamic forces on rectangular wings oscillating in subsonic flow, SAAB Aircr. Co. Linköping TN 44, 29 pp., Feb. 1960.

Author extends an approximate method presented earlier in Saab TN 41 to obtain the generalized forces for wings with straight trailing edges in subsonic flow. Method utilizes a linear combination of suitably chosen functions for the integrated acceleration potential of the reversed flow, and satisfies the velocity boundary condition over the wing in the least squares sense. Generalized forces pertaining to Legendre polynomial deflection modes are presented for rectangular wings of A.R. = 0.872, 2, 2.4, 3 at $M = 0$ and A.R. = 2 at $M = 0.9$ for several reduced frequencies. Some lift distributions at steady state are also shown for the A.R. = 2 wing at $M = 0$ and 0.9. Comparison of the results of the above theory with other theoretical and experimental results in the literature is good. Author plans to present results for cropped delta wings in a subsequent report.

J. Dugundji, USA

6353. de Vries, G., Technique of harmonic excitation used for the study of vibrations in flight (in French), Bull. Assn. Tech. Marit. Aero. no. 59, 441-464, 1959.

Author describes method of flight-testing aircraft structures for characteristic frequencies and damping coefficients using electromechanical transducers and detectors with continuous, variable frequency excitation. Method of harmonic analysis is described which allows method to be used under conditions of extremely poor signal/noise ratio in detectors occurring during flight. Theory of method is given with results for variation of characteristic frequency and damping as a function of air speed for the "Caravelle" aircraft. References, mostly to French journals, are given.

K. W. Hillier, England

Aeronautics

(See Revs. 6104, 6202, 6203, 6209, 6211, 6318, 6321, 6323, 6384)

Astronautics

(See also Revs. 5864, 6166, 6276, 6321)

Book—6354. Brouwer, D., and Clemence, G. M., Methods of celestial mechanics, New York, Academic Press, 1961, xii + 598 pp. $15.50.

Celestial mechanics enjoys a renaissance due to space applications. This rediscovery of celestial mechanics results mostly in quantity and seldom is the profession fortunate enough to receive publications of high quality comparable to the famous treatises of Tisserand, E. W. Brown, Charlier, Brown and Shook, Poincaré, Newcomb, etc.

It is this reviewer's pleasant duty to report that the qualitative renaissance has arrived with the publication of Professor Brouwer's and Dr. Clemence's long-awaited book. The dean of pertubation theories and the nation's highest authority on ephemerides calculations have presented the subject in a clear, unambiguous, error-free, and unmistakably masterly fashion.

Workers in the field have long felt the need for an authoritative, modern treatise which could be used by advanced students as well as by research workers. One of the greatest merits of the book is that the methods presented are developed from basic principles and instead of the ad hoc, deus ex machina approach—to be found in many contemporary books in the same and closely related fields—a systematic rationale permits the use of the book for self study. The balance between theoretical treatment and practical applications is carefully maintained. The analytical phases are closer to theoretical physics than to precise mathematics and the applications are closer to astronomy than to the engineering science of trajectory calculations, often called astrodynamics. While the book is neither a Wintner-type mathematical analysis nor an engineering handbook, it is most comprehensive regarding the practical aspects of dynamical astronomy without sacrificing soundness.

This review would not be complete without references to the many strong feelings and prejudices of the workers in the field. Addicts of matrix and vector notation unhappily will find that celestial mechanics, least squares method, etc., can be presented, using scalar notation. Addicts of canonical variables will enjoy the forceful and sound approach offered by their use, once the method is mastered. Devotees of analysis will be shocked by the presentation of orbit determination and computation methods without first proving the existence of the orbits. Inventors of artificial satellite orbit computation methods will be disappointed in seeing that their problem has been solved but the disappointment will be compensated when they read the most complete general perturbation solution (drag included!) presently in existence, described with elegance and clarity. Students of celestial mechanics will enjoy the excellent treatment given to the Hill equation, for instance, while engineering students will miss discussion of nongravitational forces. Beginners will find that there is no royal road to celestial mechanics, readers of the engineering profession will find the necessity of building bridges along the road, but in general it will be observed that the book offers a pleasant and comfortable ride from elementary principles to the most sophisticated methods.

Main subjects are: elliptic motion and expansions, bodies of finite dimensions, calculus of finite differences, numerical integration, abberation, comparison of observation and theory, method of least squares, differential correction, general integrals, variation of constants, lunar theory, perturbation theories, Hansen's methods, canonical variables.

The book obeys classical traditions in its construction; the index is almost useless because of the shortage of entries, and "challenging problems" which try the reader's patience are fortunately missing, being replaced by excellent and informative "notes and references" after each chapter.

V. G. Szebehely, USA

Book—6355. Jacobs, H., and Burgess, E., editors, Advances in the astronautical sciences, Vol. 6 (Proceedings of the 6th Annual Meeting of the American Astronautical Society, New York City, Jan. 18-21, 1960), New York, The Macmillan Co., 1961, lxix + 898 pp.

Complete texts of three special addresses, of one panel discussion, and of 57 technical papers delivered at title meeting are included. The papers are grouped in 9 sessions as follows: space communications, propulsion, guidance and control, space medicine and astrobiology, space flight mechanics, space vehicle design, space vehicles and re-entry, application of astronautical systems, and space physics.

Book is an impressive collection of learned papers by workers in the field; nevertheless, this reviewer wonders whether a few state-of-the-art, summary-type lectures delivered by a few selected authorities would not have benefited the profession more.

V. G. Szebehely, USA

6356. Wen, W. L.-S., A study of cotangential, elliptical transfer orbits in space flight, *J. Aerospace Sci.* **28,** 5, 411-417, May 1961.

Simple formulas are presented for obtaining transfer orbits between coplanar, noncoaxial conics. Geometrical and numerical computing procedures are given. Application to optimization problems is indicated.

W. A. Mersman, USA

6357. Duke, W. M., Goldberg, E. A., and Pfeffer, I., Error analysis considerations for a satellite rendezvous, *ARS J.* **31,** 4, 505-513, Apr. 1961.

The guidance system of satellite intended to meet a target, such as another satellite, may be subject to various errors during powered launch, coasting, adaptation thrust, searching, acquisition and homing phases. Authors discuss the effects of these errors, both for parking orbit trajectories and direct ascent trajectories, and propose methods for meeting target with terminal errors not exceeding 50 ft and 3 ft/sec.

P. M. Treuenfels, USA

6358. Musen, P., On the motion of a satellite in an asymmetrical gravitational field, NASA TN D-569, 20 pp., Jan. 1961.

Tracking precision and observation intervals of existing satellite data are sufficient for determining only the zonal harmonics in the geoid. With the availability of more accurate data extending over longer time intervals, it will become possible to determine also the tesseral harmonics in the gravitational field. The theory presented here was developed in anticipation of this fact; it extends the author's recently published work to permit each inclusion of the influence of tesseral harmonics, and of gravitational anomalies in the theory of the artificial satellite.

From author's summary by S. Lampert, USA

6359. Gilvarry, J. J., Escape of planetary atmospheres: Part 1, Escape layer; Part 2, Lifetimes of minor constituents, *Physics of Fluids* **4,** 2-12, Jan. 1961.

In Part 1 the critical layer for thermal escape of a planetary atmosphere is treated on a model in which an isothermal exosphere at high temperature merges within a narrow zone (the endopause) of varying temperature into the remainder (the endosphere) of the atmosphere, isothermal above the level at which mixing stops. Only one major constituent of the atmosphere is considered, and constant scale heights are assumed for the exosphere and for the endosphere above the level at which diffusion sets in. The height of the escape layer is evaluated analytically by considering the pressure balance at the base of the exosphere. The result permits one to determine explicitly the amount (the concentration or the number of molecules above unit area) of a minor constituent at the critical level, taking thermal diffusion across the endopause into account. The predicted height of the escape layer as determined from a model atmosphere of Nicolet shows essential agreement with the height inferred directly by means of the number density, scale height, and collision diameter.

Part 2 shows that the essential parameter determining the escape rate is the ratio to the exospheric scale height of the radius of the escape layer as measured from the planet's center. The result of the analysis is to replace Spitzer's parameter B by a modified value A_i for the lifetime of the ith minor constituent. This revision properly takes into account the effect on a minor constituent's lifetime of the difference in temperature between the escape layer and the endosphere. Correctly, the ratio of the minor constituent's molecular weight to a mean value for the atmosphere enters into A_i as a factor; the need for this particular correction to B has been pointed out previously by Nicolet and by Bates and McDowell. Numerically, it is found that A_i and B do not differ drastically for the case of He^4 in the earth's atmosphere. Computations by Spitzer and by Urey for the loss of He^4 from the earth are brought into agreement by revision of the data employed by the former, and thus the discrepancy between corresponding temperatures implied for the escape layer is removed.

From author's summary

6360. Weirauch, R. F., On the accuracy of an elliptical orbit determination, NASA TN D-573, 13 pp., Jan. 1961.

This paper discusses the problem of determining variations in the six orbital elements of a planetary body when one or more of the original observations are affected by known errors. Differential expressions are derived for these variations which eliminate the necessity of re-computing the orbit several times. A numerical example is included in which results of the use of these expressions are compared with actual residuals obtained from two orbital calculations of the same asteroid.

From author's summary by S. Lampert, USA

6361. Grantham, W. D., Effects of mass-loading variations and applied moments on motion and control of a manned rotating space vehicle, NASA TN D-803, 40 pp., May 1961.

Author gives an analytical study to determine the effects of mass-loading variations and onboard rotating machinery on an earth-satellite space station, rotating to provide an artificial gravity equal to one-fourth of that at the earth's surface. The obtained results indicate that the shifting of masses within the rotating craft could bring about oscillations in the attitude angles and even instabilities of the rotational motion. To reduce the undesirable motions, constant-rate inertia wheels and jet-reaction moments can be used. Reviewer suggests that some of the considerations should be completed because the calculations are based on the well-known system of Euler equation, valid only for a body-fixed system of coordinates and *rigid* bodies. For the problem in question the derivatives with respect to time of moments of inertia and products of inertia cannot be neglected.

K. Magnus, Germany

6362. Perkins, F. M., Transit angle for low-thrust spacecraft, *J. Aerospace Sci.* **28,** 5, 419-420 (Readers' Forum), May 1961.

6363. Bennett, A. G., A note on the motion of a spinning rocket with eccentric thrust, *J. Aerospace Sci.* **28,** 5, 426-427 (Readers' Forum), May 1961.

6364. Brissenden, R. F., Burton, B. B., Foudriat, E. C., and Whitten, J. B., Analog simulation of a pilot-controlled rendezvous, NASA TN D-747, 51 pp., Apr. 1961.

Fixed-base simulator and analog computer gave 6 degrees of freedom. Single main thrusting rocket plus attitude controls is used. Results show pilot completes rendezvous over wide range of initial conditions.

C. R. Freberg, USA

6365. Holl, H. B., The effect of radiation force on satellites of convex shape, NASA TN D-604, 53 pp., May 1961.

Author presents a comprehensive discussion of optical properties of common materials and resulting radiation force due to reflection on several concave-shaped bodies. Optical properties discussed in detail include transparency, absorption and reflectivity variation with angle of incidence and spectrum of incident radiation. Force on arbitrary body is expressed in general aerodynamic form:

$$F = p_0 A C_F$$

Author derives expressions for C_F of flat plate, sphere, cylinder, cone, and parabolic surface. Calculations are limited to bodies with specific fixed orientations relative to incident radiation such as cylinder with axis normal to radiation. Curves of C_F are given as functions of angle of incidence and reflectivity for body shapes is discussed. Paper is valuable in that method of approach can be extended to computations for other specific body orientations and body shapes.

R. McElvain, USA

6366. Nichols, L. D., Effect of shield position and absorptivity on temperature distribution of a body shielded from solar radiation in space, NASA TN D-578, 41 pp., Jan. 1961.

An analytical study of temperature distributions on two disks subjected to solar radiation has been made. The disks are oriented such that the first disk completely shields the second disk from solar radiation, and both disks are normal to the radiation. The effect on the temperature distribution of absorptivity, thermal conductivity (for two special cases), and the spacing between disks has been studied.

Calculations show the possibility of using a movable shield as a temperature control device for a space vehicle. Adjustment of the shield separation distance provides a compensation for possible changes in surface radiation characteristics and the consequent alteration in the equilibrium temperatures. Even for very small conductivities it was found that spacing distances of one-half the disk radius or greater (depending upon the absorptivity) do not introduce excessive temperature variations either on the shield or the shielded object. However, in this case, the range of temperature control is greatly reduced.

From author's summary by S. Lampert, USA

6367. Jenness, J. R., Jr., Temperatures in a cylindrical satellite (in English), *Astronaut. Acta* **6,** 5, 241-246, 1960.

Formulas are derived for temperatures inside a cylindrical instrument package in which heat from power-dissipating components must be conducted through a bulkhead to the skin and radiated. Thermal design considerations are discussed for such a package with constant skin temperature and periodically varying skin temperature.

From author's summary

6368. Patterson, G. B., Graphical method for prediction of time in sunlight for a circular orbit, *ARS J.* **31,** 3, 441-442 (Tech. Notes), Mar. 1961.

6369. James, R. L., Jr., and Harris, R. J., Calculation of wind compensation for launching of unguided rockets, NASA TN D-645, 52 pp., Apr. 1961.

A method for calculating wind compensation for unguided missiles is derived which has a greater degree of flexibility than the previously proposed methods. Most of the earlier theories were based on a common set of assumptions. These limitations are eliminated in this analysis by using a three-dimensional trajectory simulation with arbitrary wind and nonlinear aerodynamic coefficients. Utilization of the wind-compensation technique is demonstrated by using the Shotput vehicle as a model.

From authors' summary

6370. Wyatt, P. J., Induction drag on a large negatively charged satellite moving in a magnetic-field-free ionosphere, *J. Geophys. Res.* **65,** 6, 1673–1678, June 1960.

An induction drag, experienced by a charged satellite during its traversal of the ionosphere, has been theoretically postulated by several authors. Previous "exact" treatments of the problem are inapplicable to large systems, and the semiempirical approach of Jastrow and Pearse may yield somewhat questionable results. The present description initially considers the satellite as a completely permeable spherical shell of charge, thus avoiding the difficult boundary conditions introduced by the "exact" linearized treatment. The effects of permeability are then shown to be approximately removable by means of an iterative process. A final result, apparently valid to within an order of magnitude, is obtained for the drag force arising *solely* from electrical effects. Its magnitude is considerably less than that obtained by Jastrow and Pearse. From author's summary

6371. Rytov, S. M., What an astronaut will see and encounter when flying at a speed approaching that of light, *ARS J.* **31,** 5, 678–681 (Russian Suppl.), May 1961.

Ballistics, Explosions

(See also Revs. 6180, 6324, 6354, 6355)

6372. Wood, W. W., Existence of detonations for small values of the rate parameter, *Physics of Fluids* **4,** 1, 46–60, Jan. 1961.

Author discusses the existence of solutions of the reactive Navier Stokes equations corresponding to the one-dimensional, steady-state, detonation wave with an irreversible, unimolecular chemical reaction and no heat loss. An ignition temperature is assumed in order to obtain a steady cold boundary condition. Detonation solutions are shown to exist for arbitrarily small values of reaction rate. Such solutions approach the von Neumann detonation model of a steady deflagration wave following a shock in the unreacted material. Paper resolves a problem posed by earlier papers by Hirschfelder, Curtiss et alia [AMR **12**(1959), Rev. 2121] who found it impossible to obtain satisfactory solutions by numerical integration for values of a reaction rate parameter less than a critical value. G. K. Adams, England

6373. Adamson, T. C., Jr., On the structure of plane detonation waves, *Physics of Fluids* **3,** 5, 706–714, Sept./Oct. 1960.

Author obtains an analytic, closed form, perturbation solution for the flow through a reaction zone initiated by a shock, the case treated numerically by Linder, Hirschfelder, and Curtiss [AMR **12**(1959), Rev. 2121]. Small perturbation parameter is of the order of the ratio of a characteristic collision time to reaction kinetic time. Both reversible and irreversible reactions are considered. Range of validity of the solution is carefully delimited. Title notwithstanding, paper is less a contribution to wave structure theory than a simple quantitative description of the results of a theory. C. M. Ablow, USA

6374. Miles, J. W., The propagation of an impulse into a viscous-locking medium, *ASME Trans.* **83** E (*J. Appl. Mech.*), 1, 21–24, Mar. 1961.

Original model of a "viscous-locking" medium is proposed in order to represent the behavior of an uncompacted soil subjected to very high pressure. Considering an impulse loading applied to a half space in the case of purely locking medium a general solution is given for the disturbance produced by an arbitrary pressure. The neglect of viscosity implies a jump in strain and the compaction wave becomes a shock front. It is concluded that compaction causes the peak pressure to fall off inversely as the square of the impulse. The assumption of a constant impulse gives an asymptotical approximation of the problem. Similarity solution (analogy with heat conduction) is presented for a concentrated impulse acting on a viscous half space. Viscosity reduces the peak pressure by retarding the compaction wave. The peak pressure falls off inversely as the square of the depth as for the locking medium. Z. Bychawski, Poland

Acoustics

(See also Revs. 6027, 6048, 6114, 6173, 6316)

6375. Werner, P., Mathematical theory of acoustical fields (in German), *Arch. Rational Mech. Anal.* **6,** 3, 231–260, Nov. 1960.

This study is the first of three studies, which constitute a thorough approach to the mathematical theory of stationary acoustical wave fields in nonhomogeneous media. Author considers first the physical basic principles involved in the Helmholtz wave equation $\nabla^2 U + K^2 U = 0$ where U = a velocity potential function, K a constant. The boundary conditions are examined from a physical standpoint. The solutions of the equation which satisfy the radiation conditions are studied and it is shown that there cannot exist more than one solution satisfying the boundary conditions. A time-independent equation of the type

$$\rho_0 \nabla\left(\frac{1}{\rho_0}\nabla U\right) + \kappa^2 U = 0$$

is then considered with

$$\rho_0(x) = \begin{cases} \rho_{01}(x) \text{ for } x \in \text{Domain (1)} \\ \rho_{02}(x) \text{ for } x \in \text{Domain (2)} \end{cases} \qquad \kappa(x) = \begin{cases} \dfrac{\omega(\omega + i a_1)}{c_1(x)^2} \text{ for } x \in G_1 \\ \dfrac{\omega(\omega + i a_2)}{c_2(x)^2} \text{ for } x \in G_2 \end{cases}$$

where ρ_0 is the variable density of the fluid, ω the wave frequency, c the velocity field distribution, a a positive damping factor and f a function characterizing the homogeneity of the medium.

The numerical analysis leading to the calculation of U is done using Fredholm integral method and the method of C. Müller exposed in his mathematical theory of electromagnetic waves (Springer edition, Berlin, 1957). G. E. Jarlan, Canada

6376. Gottlieb, P., Sound source near a velocity discontinuity, *J. Acoust. Soc. Amer.* **32,** 9, 1117–1122, Sept. 1960.

A general approach is given for the approximate determination of the distant sound field in one semi-infinite layer of medium moving at a uniform Mach number M_2 from a stationary line source situated near the plane interface in the adjacent semi-infinite layer which is moving at a uniform Mach number M_1. The line source is represented by a plane wave expansion and the saddle-point method is used to obtain the asymptotic approximation to the far field. Field distributions are shown for (1) $M_2 = 0$, $M_1 = 0.3$ and 1.2, (2) $M_1 = 0.3$, 0.7, and 1.2. An extension of the theory to a point source is shown. It is indicated that the transmitted wave behavior in this case is fundamentally the same as for the line source. W. W. Soroka, USA

6377. Lyamshev, L. M., Reflection of sound from a moving thin plate, *Soviet Phys.–Acoustics* **6,** 4, 505–507 (Brief Comm.), Apr./June 1961. (Translation of *Akust. Zh., SSSR* **6,** 4, 505–507, Oct./Dec. 1960 by Amer. Inst. Phys., New York, N. Y.)

6378. Brockhurst, R. R., Bruce, J. G., Jr., and Arons, A. B., Refraction of underwater explosion shock waves by a strong velocity gradient, *J. Acoust. Soc. Amer.* **33,** 4, 452–456, Apr. 1961.

The effects of a strongly refracting summer thermocline on the initial pressure pulse from an underwater explosion were accurately measured in a flooded quarry. The familiar exponentially decaying pulse shape was observed to be drastically altered in highly divergent regions of the field. Closely spaced measurements permitted these shape changes, as well as the increased amplitude and decreased time constant in a caustic region, to be followed continuously from the source. It is presently impossible to compute the observed pulse shapes, although measured shock pressures agreed well with ray-theory predictions except near the caustic. Measured travel time differences between initial arrivals and both second direct arrivals and surface reflections agreed quite exactly with predictions. From authors' summary

6379. Hale, F. E., Long-range sound propagation in the deep ocean, *J. Acoust. Soc. Amer.* **33,** 4, 456–464, Apr. 1961.

The high intensity and low distortion of underwater acoustic signals propagated to convergence zones justifies a comprehensive description and an effort toward better organization of pertinent and related information. Convergence zones are the result of SOFAR Channel propagation from shallow sources to shallow receivers. The acoustic paths are analogous to those of skip-wave radio transmission. Although only illusive references exist in the open literature, there have been experiments showing as many as thirteen well-formed zones spaced over a 400-mile range interval. The propagation is quantitatively predictable, and quite stable. Convergence of acoustic energy along caustics results in losses smaller by about 20 db than those encountered in a free field. From author's summary

Book—6380. Beranek, L. L., edited by, Noise reduction, New York, McGraw-Hill Book Co., Inc., 1960, x + 752 pp. $14.50.

Problems related to noise and its reduction have grown in importance in recent years. Book is based on a series of special summer programs at MIT for graduate engineers, and forms an excellent text for such a course. Although each of the twenty-five chapters has its own author, the various chapters are well coordinated, using ideas developed in previous chapters and guiding reader to following chapters. Different aspects of noise reduction are covered thoroughly in the four parts of the book, viz., "sound waves and their measurement," "fundamentals underlying noise control," "criteria for noise and vibration control," and "practical noise control." Numerous illustrative examples, many taken from engineering practice, emphasize practicality of topics discussed. Sufficient derivations and definitions are presented to make entire book unambiguous.

Reviewer felt book was easy to read and well organized. Both general considerations and practical details appear well presented and currently useful. In a few places, reviewer was irritated by a tendency to stress the obvious or to introduce complex approximations rather glibly, but these were exceptions. Book is not meant to be a compendium or series of tables for engineers already engaged in noise reduction. Its maximum value will be for graduate engineers about to embark on a career in the area of noise reduction. It also should be of value to architects, factory executives, city planners, and others who want to use their acoustic knowledge to gain an appreciation of factors which must be considered by consultants they employ to reduce noise. Finally, it is a pleasant book for persons, such as the reviewer, who are engaged in other fields of acoustics and are interested to learn what noise-reduction engineers are doing. E. Ackerman, USA

6381. Furduev, V. V., and T'ung, C., Measurement of diffuseness of the acoustic field in rooms by the directional microphone method, *Soviet Phys.-Acoustics* **6,** 1, 103–111, July/Sept. 1960. (Translation of *Akust. Zh., USSR* **6,** 1, 107–115, Jan./Mar. 1960 by Amer. Inst. Phys., New York, N. Y.)

Microphones having a response which varies with the angle ϑ between the axis of the microphone and the direction of sound propagation are useful for measurement of the diffuseness of a sound field. The response as a function of ϑ is the "directivity characteristic". The sound field in a reverberant room or enclosure might have waves whose intensities in different directions are a function of the same angle θ. In an ideally diffuse field the intensities will be the same for all directions of propagation. The authors show, with the help of simple mathematics, how to deduce a quantitative measure d of the degree of diffusion from observations made with a microphone of arbitrary directivity characteristic. This is accomplished by rotation of the microphone in the sound field, and study of the voltage produced as a function of the angle of rotation. The principles are illustrated with measurements made with two types of microphones, whose directivity characteristics have (1) a figure-of-eight shape, and (2) a cardioid shape. Values of d are measured for a studio and a reverberant chamber at various frequencies in the audio range. R. K. Cook, USA

6382. Heckl, M., Sound insulation of a homogeneous finite simple wall surface (in German), *Acustica* **10,** 2, 98–108, 1960.

Author calculates the sound insulation of partition walls with vertically adjacent side walls. The calculation brings out a marked influence of the side walls (i.e., boundary conditions) on the sound insulation especially above the coincidence frequency. It is shown that the insulation is independent of the wall, and of its boundary conditions, only if less energy is transmitted into the side walls than is absorbed by internal friction. From author's summary by J. Miklowitz, USA

6383. Kosten, C. W., The mean free path in room acoustics (in English), *Acustica* **10,** 4, 245–250, 1960.

The mean free path of an enclosure—which is of practical use in diffuse sound fields—is shown to be four times the ratio of volume over surface (4 V/S). This holds without any approximation for all room shapes.

In the rather extensive literature on this important quantity a straightforward and simple derivation could not be found. Discrepancies from 4 V/S, reported in literature, are discussed and explained. From author's summary

6384. Maglieri, D. J., Hilton, D. A., and Hubbard, H. H., Noise considerations in the design and operation of V/STOL aircraft, NASA TN D-736, 16 pp., Apr. 1961.

6385. Ferrero, M. A., and Sacerdote, G. G., The acoustic impedance of thin layers of porous material (in English), *Acustica* **10,** 5/6, 1960.

The behavior of the real component of the acoustic impedance of a thin layer of porous material adhering to a rigid wall is studied; this component increases greatly when the layer becomes very thin. From authors' summary

6386. Heller, H., Noise generated by the gas streams leaving jets (in German), *ZVDI* **103,** 11, 489–490, Apr. 1961.

6387. Spurr, R. T., The ringing of wine glasses, *Wear* **4,** 2, 150–153, Mar./Apr. 1961.

6388. Meyer, E., Dinkelacker, A., and Tamm, K., Flow noise in water-filled tubes (in English), *Acustica* **10,** 5/6, 322–325, 1960.

6389. Kallistratova, M. A., and Tatarskii, V. I., Accounting for wind turbulence in the calculation of sound scattering in the at-

mosphere, *Soviet Phys.-Acoustics* **6,** 4, 503–505 (Brief Comm.), Apr./June 1961. (Translation of *Akust. Zh., SSSR* **6,** 4, 503–505, Oct./Dec. 1960 by Amer. Inst. Phys., New York N. Y.)

6390. Tack, D. H., Smith, M. W., and Lambert, R. F., Wall pressure correlations in turbulent airflow, *J. Acoust. Soc. Amer.* **33,** 4, 410–418, Apr. 1961.

The correlation properties of turbulent wall pressure fluctuations are investigated experimentally with a view toward developing an adequate phenomenological model of the pressure correlation function for use in engineering calculations. It was found that both mean eddy sizes and mean eddy lifetimes determined by averaging over broad frequency bands did not contain sufficient information to accurately describe the high frequency end of the turbulent power spectrum. Thus, such gross quantities are of somewhat limited utility in detailed analysis, for instance, in predicting response of multimodal mechanical systems driven by flowing turbulence. However, by measuring eddy sizes and lifetimes over narrow frequency bands it appears possible to construct mathematical models for the turbulent pressure correlations which are successful in predicting the turbulent power spectrum over the frequency band of interest which could include the entire spectrum. In addition, measurements of rms pressure and space-time correlations are presented which supplement the data obtained by W. W. Willmarth [NASA Memo. 3-17-59 W (1959)] for a somewhat higher Mach range. From authors' summary

Micromeritics

(See also Rev. 6037)

6391. Vanoni, V. A., and Nomicos, G. N., Resistance properties of sediment-laden streams, *Trans. Amer. Soc. Civ. Engrs.* **125,** part 1, 1140–1175, 1960.

The well-known fact that in the sediment-laden stream over a sand bed the resistance to flow changes with regard to the stream of clear water in the same flow conditions was examined experimentally. An investigation of 4 sets with 25 runs of experiments was made in an effort to separate two factors affecting the change in resistance. A summary of given results demonstrates that a sediment-laden stream flowing over a bed of sand—by using 0.091-mm mean diameter sand—reduces the Manning roughness coefficient n—in the limits of experiments—in an amount varying from 3% for lower sediment discharge concentration and flow over large dunes to 13% for higher concentrations and flow over flat beds. The double effect affecting this change in coefficient is due to the smoothing-out of the bed configuration which tends to reduce the coefficient as the velocity increases and to a damping of the turbulence by suspended sediments which tends to increase the velocity gradient by decreasing momentum transfer. This damping in the turbulence motion follows as a result of the work which must be done by vertical components of turbulence fluctuations to keep sediment in suspension. The change in roughness coefficient due to bed configuration is larger than that due to damping effect. Several field data are in agreement with flume studies but it is impossible to distinguish in the field between the factors affecting the resistance.

The discussion demonstrates that the authors have opened a new view to the problem but that it is probably much more complicated than related in the paper. The reviewer believes that the problems in relation to the resistance properties of sediment-laden streams were treated also in 28 articles and reports mentioned in this paper; also in several reports given at the National Congress of Hydraulic Research at Brno (Czechoslovakia) in October 1959 concerned with the same problems.

J. J. Bleiweis, Yugoslavia

6392. Tesarzhik, I., On the theory of heavy granular and flocculent particles in fluid flow (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 6, 27–35, Nov./Dec. 1959.

6393. Kneschke, A., and Schock, M., Evaluation of general sieving residual curves (in German), *Freiberger Forschungshefte* (A) 130, 11–25, 1959.

Based on the Rosin-Rammler-Sperling (RRS) exponential function for fineness and uniformity of granular goods, a general theory is presented for any residual function. Authors derive, by detailed mathematical analysis, a distribution function for surface from a distribution function for weight, and also formulas for the total surface area as a function of weight and specific gravity, and an expression for the mean grain size. Quantities entering into these formulas are: total volume, smallest and largest grain size, form factor ("Heywood-factor"), and the sieving residuum as function of grain size. Paper presents an expression also for the uniformity of grain goods, which is the reciprocal value of surface distribution. Concepts and procedures are explained by means of a numerical example.

This is a comprehensive treatment of the statistical analysis and description of granular goods. While the investigation is based on the properties of powdered coal and coal dust, and had for its purpose the quantitative definition of their characteristics, the mathematical results here presented have applicability to other comminuted materials such as powdered lime, plaster of paris, flour, and other similar powders and dusts.

K. J. DeJuhasz, USA

6394. Leeden, P. v. d., and Bouwhuis, G. J., Tentative rules for shearing stresses in particulate fluidized beds, *Appl. Scient. Res.* (A) **10,** 1, 78–80 (Letter to the Editor), 1961.

6395. Morgan, B. B., The adhesion and cohesion of fine particles, a review, *Brit. Coal Utilisat. Res. Assn., Mo. Bull.* **25,** 4, 125–137, Apr. 1961.

6396. Sandomirskii, M. G., Influence of the condition of the surfaces of jet orifices in the atomizers of diesel nozzles for spraying the fuel (in Russian), *Nauchn. Zap. Khar'kovsk. In-ta Mekhaniz. S. Kh.* no. 11, 57–62, 1958; *Ref. Zh. Mekh.* no. 10, 1959, Rev. 11632.

Results are given for the experimental comparative investigation of the influence of roughness of the nozzles of spray burners (made by the electro-erosional method) and of the ordinary drilled nozzle on the quality of the spraying of the fuel. The comparison of the quality of the spraying was carried out by the determination of the range and the angle of spread of the atomized fuel when the spraying was done at identical pressures into a medium of the same density ($\gamma = 17$, which corresponds to the density of the air in the motor's cylinder at the end of the compression stroke). The experiments were made with special apparatus by high-speed photography of the cone of spray in natural size and in relation to time. The experiments show that at high pressures of atomization in a rough nozzle the range of the cone of spray grows smaller, while the angle of spread gets larger by comparison with these characteristics for a drilled nozzle. Consequently it would be expedient to manufacture the jet orifices of the nozzles by the electro-erosional process. Yu. f. Dityakin

Courtesy Referativnyi Zhurnal, USSR

6397. Schmitt, K., Quantitative investigations on the precipitation of dust in diffusing steam (in German), *Staub* **21,** 4, 173–177, Apr. 1961.

Aerosol particles, suspended in a carrying gas through which a vapor passes by diffusion, are subjected to a force in the direction

of the diffusion stream. The effect is similar to thermal diffusion acting in a temperature gradient in the direction of heat flow. Past research work on this subject, by Facy, Stetter, and others, is reviewed, then present experiments are described in detail. The velocity of oil droplets was measured in a special suspension condenser, by diffusion of water steam through nitrogen as carrying gas. The measurements were made at pressures of 400 down to 100 mm Hg, whereby it was possible to study the behavior of droplets which are small or large compared with the free path of the gas molecules. Experimental apparatus is described and illustrated; its calibration is explained. Mathematical theory of the motion of particles in a diffusing steam is given. Experimental results are presented in charts. The results obtained show that dust can be precipitated by condensation of steam on solid surfaces, or on suspended condensation nuclei and droplets. These phenomena are brought into relationship with the self-purification of the atmosphere inside clouds, with dust precipitation in a venturi separator, and with some other industrial processes. A bibliography of 18 titles covers the pertinent literature between 1943 and 1961. K. J. DeJuhasz, USA

6398. Louzhnov, G. K., Zverev, N. I., and Gavrilov, A. F., An experimental determination of resistance coefficients in conditions of pneumatic transportation of pig iron shot (in Russian), *Teploenergetika* no. 1, 15–18, Jan. 1961.

6399. Klyachko, L. S., Savina, A. A., and Getmanskaya, M. V., A ventilating with wet dust separator (VMP-LIOT) (in Russian), Prom. Ventilyatsiya, Leningrad, 1958, 22–32; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13384.

A description is given of the ventilator with wet dust separator (VMP-LIOT); results of an experimental investigation of the machine are included. The high effectiveness of this principle in dust removal is established and it was shown that the degree of purification of the air does not depend on the specific consumption of water when that figure is altered from 0.3 to 1.0 l/m^3. The proposed principle of dust separation can be put into practice with any standard centrifugal ventilator without any structural alterations and only the addition of a device for entrapping droplets.

V. A. Bashkin

Courtesy Referativnyi Zhurnal, USSR

6400. Symposium on cyclones, held on Dec. 10, 1958 at Utrecht. The six lectures appear in *Ingenieur* **71,** nos. 29, 39, 41, 43, 1959; Revs. 6401–6406.

This is the second symposium on the same subject. The first was held in 1953. The two symposia had the same aim, namely to review the present state of knowledge concerning cyclonic separation. Because of the great extent of the field a choice had to be made in order to restrict the number of papers. This choice was determined by considering only the progress and development in the Netherlands on theoretical aspects and practical applications. As regards the advance in knowledge two points have emerged from the papers. The recognition that the residence time of particles in a cyclone should be included in a fruitful theoretical attack of the separation process, and the fact that acceleration effects in the core region play an important and sometimes decisive role in the classification of particles according to shape and specific gravity.

Another important conclusion of the symposium was that, notwithstanding the above progress, cyclone design is still almost entirely founded on empirical observations. The main reason is our insufficient knowledge of fluid mechanics in order to predict theoretically the flow pattern in a cyclone. All fruitful theories on the separation process, including the above, are based on observed flow patterns. An important field of investigation is still open for flow specialists, while many more experiments are needed to test the assumptions made in the theories and the effect of departures from these assumptions (validity of Stokes's law, effect of turbulence, concentration effect, hindered settling, etc.).

J. O. Hinze, Holland

6401. Lenlger, H. A., Introduction, Pap. no. I, **71,** 29, 31–42, July 17, 1959.

Cyclones may be used for the mechanical separation and classification of heterogeneous mixtures of solid particles, of solid particles and liquids, of solid particles and gases, of nonmiscible liquids, and of liquids and gases. However, other apparatuses may do the job as well or even better. In order to judge the advantages and disadvantages of cyclones with respect to other apparatuses, a survey is given of the principles and basic methods of mechanical separation. A comparison is then made in this light. It is concluded that cyclones can be applied successfully for: (a) the pneumatic classification of solids; (b) the hydraulic classification of solids; (c) the concentration of suspensions of solids in liquids; (d) dust separation; (e) the separation of droplets from gases; (f) the separation of emulsions. But they are best suited as hydrocyclones (b) and dust cyclones (d).

J. O. Hinze, Holland

6402. Rietema, K., The mechanism of the separation of finely dispersed substances in cyclones, Pap. no. 2, **71,** 39, 59–68, Sept. 25, 1959.

New theory on cyclone separation includes the effect of residence time as an essential condition. Use has been made of published measured flow patterns. Theory leads to a dimensionless separation number $C_y = \frac{d^2\Delta\rho}{\eta} L \frac{P}{\rho q}$ (d = diameter of particles of which 50 per cent are separated, $\Delta\rho$ = density difference, ρ = density of fluid, η = dynamic viscosity, L = total length of cyclone, P = total pressure drop and q = capacity of cyclone). According to theory C_y is only dependent on the cyclone geometry. Measurements on a number of hydrocyclones show this dependency. For the concentration of suspensions an optimum cyclone geometry is suggested, with $C_y = 3.5$. In an appendix the effect of turbulence on the separation efficiency has been estimated; under normal working conditions this effect is shown to be small. Reviewer remarks that application of the results to dust cyclones has to occur with some reservation. J. O. Hinze, Holland

6403. Van Kooy, J. G., Some experiments concerning the effect of the Reynolds number on the separation efficiency of a hydrocyclone, Pap. no. 3, **71,** 41, 69–74, Oct. 9, 1959.

Experiments with narrow fractions of polystyrene spheres in the range from 250 to 650 micron diameter, and with various liquids with viscosities ranging from 0.155 to 0.475 cm^2/sec. Main result is that for a given cyclone design and given density ratio there is an optimum Reynolds number based upon cyclone diameter and inlet velocity at which separation efficiency is a maximum.

Reviewer's note: The effect of Reynolds number is two fold: (a) through the viscosity effect on particle motion, and (b) through the effect on the flow pattern. These separated effects can be evaluated from Rietema's separation number C_y (see preceding review) and confirm author's observations.

J. O. Hinze, Holland

6404. Fontein, F. J., Separating with a cyclone at a specific gravity higher than the carrying medium, Pap. no. 4, **71,** 41, 75–81, Oct. 9, 1959.

Interesting paper deals with the classification of particles according to shape and density, when latter is higher than that of the carrier fluid. Outlet of flow is through an overflow and an under-

flow with concentration of the "heavier" particles in the underflow. This classification or "washing with water" is based upon acceleration effects on the particles mainly in the core region of the cyclone.

Paper describes principles of this "washing with water" as well as applications. J. O. Hinze, Holland

6405. Havenaar, I., The separation of clay and barytes in drilling fluids by means of hydrocyclones, Pap. no. 5, **71,** 43, 83–88, Oct. 23, 1959.

Experiments with a 3-inch diameter cyclone for evaluating the effects of pressure drop, dilution ratio (which is the ratio by volume of water and mud) and diameter of underflow outlet. Results show an increased barytes recovery with increasing pressure drop, and increasing dilution ratio up to 5 after which the improvement is only slight. For the cyclone tested an optimum underflow outlet diameter of 0.6 inch was observed. Comparison with the theory expounded in Rietema's paper (This issue, Rev. 6402) gives satisfactory agreement. J. O. Hinze, Holland

6406. Van der Kolk, H., Developments on gas cyclones, in particular on cyclones placed in series, Pap. no. 6, **71,** 43, 89–94, Oct. 23, 1959.

In fact paper considers only two subjects: The beneficial effect of water addition on the separation efficiency of a cylindrical cyclone with tangential inlet and outlet, and a theoretical study of the total separation efficiency of two cyclones in series. This forms the main part of the paper. Theory assumes simple functions for the size frequency distribution of the particles and for their fractional separation efficiency. Three different arrangements of the two cyclones in series are considered. From the theoretical results it is concluded that though in general an improvement is reached with two cyclones in series, depending on the characteristics of the separate cyclones, there may be cases where an adverse effect is obtained. J. O. Hinze, Holland

End of Symposium

Porous Media

(See Revs. 6076, 6286)

Geophysics, Hydrology, Oceanography, Meteorology

(See also Revs. 5844, 6096, 6294, 6300, 6354, 6359, 6389)

Book—6407. Problems in engineering seismology [Voprosy inzhenernoi seismologii], Trudy Instituta Fiziki Zemli **2,** 5(172); Moskva, Izdatel'stvo Akad. Nauk SSSR, 1959, 192 pp. 9 r 50 k.

This book contains a number of papers of unequal interest. The most interesting is *S. V. Medvedev* —Researches on the vibrations of buildings due to earth tremor (p. 131–194). It is a study of certain particularities of seismic vibrations of the ground and of buildings as well as their interaction. Beginning with the differential equations of the movement, the transverse vibrations of a rigid rod are studied; it is shown that an integral equation is the adequate mathematical statement of the problem. The principal point of the paper is the study of methods for the computation of the fundamental period of the vibration of a building using the similarity of the building to a beam of variable section. Energy considerations are used to establish a precise formula for the fundamental tone; an empirical formula is given for the harmonics.

The theory is illustrated by many examples: Theoretical and practical study of vibrations of houses, of a water-tower, of a chimney, and so on.

In this paper the elastic deformations only are taken in the account.

Other papers:

N. A. Vvedenskaya, N. V. Kondorskaya—Bulletin of intense earthquakes in SSSR, 1956 (p. 3–19).

Results of observations with and without seismographs.

A. Z. Katz—Some questions about methods for the division of the ground surface in seismic micro-districts (p. 20–59).

Nature of grounds from seismic point of view. An adequate means to characterize the ground is the study of dynamic deformation due to the seismic waves. These deformations can be evaluated if the physical characteristics of the ground are known and some observations done on the area.

S. V. Medvedev—Connection between the depth of focus of an earthquake and the isoseists (p. 94–99).

The depth can be determined if the distances between the isoseists and the epicenter are known.

N. V. Shebalin—Determination of the depth of the earthquake, the layer of low velocity being taken into consideration (p. 100–113).

A chart is given for the graphical determination of the depth.

S. V. Putchkov—Instrumental study of seismic micro-districts during the earthquake of Askhabad in 1948 (p. 60–80).

It is shown that the intensity of the vibrations depends on the physical characteristics of the ground and the micro-districts correspond to the degrees of the destruction of buildings.

V. V. Popov—Geological and engineering criteria for the division in seismic micro-districts (p. 81–93).

Study of ground characteristics from seismic point of view.

R. I. Khovanova—Characteristic spectra of earthquakes in the district of Tian-Shan.

An application of Medvedev's method.

V. A. Tokmatv, D. A. Kbarine—Some modifications of the seismograph SPM-16 in order to permit the recording of accelerations of low frequency. V. N. Baranov, France

6408. Yoshiyama, R., Stability of waves through a heterogeneous medium and apparent internal friction, *Bull. Earthquake Res. Inst., Tokyo Univ.* **38,** 4, 467–478, Dec. 1960.

The problem is to study the attenuation of seismic waves and the absorbing mechanism in a heterogeneous crust. A simple case is considered: a stratified medium and a plane wave. If the medium has a periodic structure, one can obtain an approximate solution depending on Mathieu's functions. Then the value of the attenuation can be determined. When the periodically stratified medium is between two homogeneous layers, the formula is given for the nondissipative attenuation caused by this structure.

V. N. Baranov, France

6409. Savarensky, E. F., Kondorskaya, N. V., and Belotelov, V. L., On the determination of the energy of elastic waves generated by earthquakes, *Bull. Acad. Sci., USSR, Geophys. Series* no. 5, 419–425, Dec. 1960. (Translation of *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 5, 633–643, May 1960 by Amer. Geophys. Union, Washington 5, D.C.)

The total energy $\overline{E}$ emanating from an earthquake can be computed if we know (1) the energy density E_0 of the incident wave, (2) the density ρ and the propagation velocity c, (3) a function of directivity f near the focus, and (4) some other local parameters such as the angle of emergence, etc. As a matter of fact, for each station the value of

$$\text{Log } \overline{E} - \text{Log } (\rho\, c) + \text{Log } f$$

can be determined. Thanks to some simplifying assumptions, f can be calculated; therefore $\overline{E}$ is known.

A device for the evaluation of the density of the energy by the seismogram is suggested. An example is adduced of the determination of the energy of the earthquake of January 3, 1957. The values of $\overline{E}$ obtained at 36 stations seem to be coherent.

V. N. Baranov, France

6410. Khorosheva, V. V., Some results of the investigation of P_a and S_a waves from the seismograms of stations of the USSR, *Bull. Acad. Sci., USSR, Geophys. Ser.* no. 11, 1045-1049, Nov. 1960. (Translation of *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 11, 1563-1569, Nov. 1960 by Amer. Geophys. Union, Washington 5, D.C.)

By the seismograms of stations of the USSR, investigations are carried out of P_a and S_a waves, the origin of which is related by some authors to a layer with lower velocity in the upper portion of the Earth's mantle. The travel-time curves of the P_a and S_a waves, the approximate value of the geometric-divergence index, and the absorption coefficient of the P_a wave are obtained.

From author's summary

6411. Bulin, N. K., and Tryufil'kina, E. I., Utilization of converted SP waves of local earthquakes in studying the structure of the deeper crust, *Bull. Acad. Sci., USSR, Geophys. Ser.* no. 11, 1050-1055, Nov. 1960. (Translation of *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 11, 1570-1579, Nov. 1960 by Amer. Geophys. Union, Washington 5, D.C.)

Authors discuss the separation of converted SP waves on seismograms of local earthquakes. They present a method for interpreting SP wave records and their utilization in crustal studies in southeastern Turkmenia.

From authors' summary

6412. Konstantinova, A. G., Time distribution of elastic pulse energy during destruction of rocks, *Bull. Acad. Sci., USSR, Geophys. Ser.* no. 11, 1056-1061, Nov. 1960. (Translation of *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 11, 1580-1592, Nov. 1960 by Amer. Geophys. Union, Washington 5, D.C.)

Analysis of the time distribution of elastic pulse energy reveals certain aspects of the fracturing process during destruction of rock specimens under mono-axial compression, and in coal seams during periods preceding sudden discharges of coal and gas.

From author's summary

6413. Belotelov, V. L., Savarensky, E. F., and Feofilaktov, D. V., Determination of the energy of the earthquake of 11/15/59, *Bull. Acad. Sci., USSR, Geophys. Ser.* no. 11, 1062-1065, Nov. 1960. (Translation of *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 11, 1593-1597, Nov. 1960 by Amer. Geophys. Union, Washington 5, D.C.)

6414. Rykunov, L. N., Khorosheva, V. V., and Sedov, V. V., A two-dimensional model of a seismic waveguide with soft boundaries, *Bull. Acad. Sci., USSR, Geophys. Ser.* no. 11, 1069-1071, Nov. 1960. (Translation of *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 11, 1601-1603, Nov. 1960 by Amer. Geophys. Union, Washington 5, D.C.)

6415. Belotelov, V. L., and Kondorskaya, N. V., On the question of the determination of the energy of earthquakes, *Bull. Acad. Sci., USSR, Geophys. Ser.* no. 12, 1164-1172, Dec. 1960. (Translation of *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 12, 1744-1755, Dec. 1960 by Amer. Geophys. Union, Washington 5, D.C.)

Results are presented of the determination of the energy of longitudinal and transverse waves for ten Far-Eastern earthquakes, using a method which had been suggested earlier by the authors. The results that were obtained agree with the energy values that had been calculated by means of the fomula of Gutenberg and Richter, which is based upon the determination of the magnitude M for the earthquakes in question.

An attempt is made to construct an "energy hodograph"; there is a general tendency for the increase of lg E with epicentral distance for P and S waves which is estimated.

From authors' summary

6416. Konstantinova, A. G., Distortions during the recording of elastic pulses in rocks, *Bull. Acad. Sci., USSR, Geophys. Ser.* no. 12, 1178-1183, Dec. 1960. (Translation of *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 12, 1762-1770, Dec. 1960 by Amer. Geophys. Union, Washington 5, D.C.)

During seismoacoustical studies of the mechanism of the destruction of rocks, the objectives of analysis are the amplitude, the frequency spectrum, and the shape of the elastic pulses excited during the fracturing. During the recording the above parameters can be subjected to considerable distortion due to a limited separating capacity of the receiving-recording apparatus, and due to natural oscillation processes and attenuation in the medium lying between source and receiver of the elastic pulses. The errors introduced by natural oscillations during the recording of elastic pulses associated with the destruction of rocks have been examined. Author discusses the distortions to which the elastic pulses are subjected during recording of the seismoacoustical processes that accompany the destruction of coal seams in mines.

From author's summary

6417. Luecke, E. I., Experimental dependence of the energy of seismic waves on the explosive conditions, *Bull. Acad. Sci., USSR, Geophys. Ser.* no. 12, 1192-1198, Dec. 1960. (Translation of *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 12, 1782-1790, Dec. 1960 by Amer. Geophys. Union, Washington 5, D.C.)

6418. Gluzmann, A. M., The field of a point source located on the boundary of a half-plane in the presence of a dividing surface in the form of a paraboloid, *Bull. Acad. Sci., USSR, Geophys. Ser.* no. 12, 1199-1201, Dec. 1960. (Translation of *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 12, 1791-1795, Dec. 1960 by Amer. Geophys. Union, Washington 5, D.C.)

6419. Keilis-Borok, V. I., and Stesin, I. M., Dispersion of relay waves in a two-layer model of the earth's crust (in Russian), *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 1, 27-31, 1959; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14054.

An investigation is made of dispersion on the quiescent isotropic ideally elastic semispace of a two-layer model of the earth's crust when the power correlationship of the granite and basalt strata is assumed to be arbitrary and the basis of the investigation is the general theory of interference waves in a multilayered medium. A comparison of the theoretical data with the experimental showed the possibility of determining the structure of the earth's core by means of the dispersion of relay waves.

I. I. Kandaurov

Courtesy Referativnyi Zhurnal, USSR

6420. Tsvei, I. Yu., Calculations for the components of the load-carrying structures of buildings when subjected to horizontal seismic loads (in Russian), *Prom. Str-vo* no. 2, 44-50, 1959; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14435.

An investigation is made of the action of seismic loading on the load-carrying parts of a building and also calculations for the load-carrying structure; calculations made in accordance with the current standard SN8-57 are criticized and improvements are proposed.

From author's summary

Courtesy Referativnyi Zhurnal, USSR

6421. Riznichenko, Y. V., and Shamina, O. G., Multiple reflected and transmitted waves, *Bull. Acad. Sci. USSR, Geophys. Ser.* no. 12, 1129–1139, Dec. 1960. (Translation of *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 12, 1689–1706, Dec. 1960 by Amer. Geophys. Union, Washington, 5, D.C.)

A theoretical discussion is given of a problem on dispersed summarized multiple waves, reflected and transmitted refracted seismic waves in a multilayered medium with thin dispersion layers. Experiments are described on ultrasonic pulse modeling of reflection and transmission of seismic waves in a medium having thin layers. A comparison of the experimental results with theoretical computations is discussed.

From authors' summary

Book—6422. Geller, S. Iu., editor, Fluctuations and variations of river runoff [Kolebaniia i izmeneniia rechnogo stoka], Moscow, Academy of Sciences of USSR, 1960, 166 pp. $2.

This collection of 6 papers concerns the forthcoming changes in river regime due to extensive reclamation and hydraulic engineering works in Siberia, Central Asia and in China. Meaning of an average flow is discussed and method of reduction of this average to a selected period of time, mostly of limited duration, is proposed. Level fluctuations in isolated lakes are used for establishing such a period of stable hydrologic relationships. A. V. Agupov presents runoff fluctuations in rivers of Western Siberia and a map of average unit discharge for that region. N. T. Kuznetsov and I. S. Sosedov discuss runoff fluctuations in deserts of northern Kazakhstan. M. I. L'vovich investigates variations of runoff under influence of agricultural uses. G. V. Nazarov analyzes natural and human factors of runoff in southern Volga River region. Another article emphasizes effect of soil cultivation in the same region. M. I. L'vovich scrutinizes variations in Hwangho River regime in connection with huge reclamation works in its drainage area. The entire set is of particular value due to new and accurate data. S. Kolupaila, USA

6423. Pokhunkov, A. A., A study of the neutral composition of the upper atmosphere at altitudes above 100 km, *Bull. Acad. Sci., USSR, Geophys. Ser.* no. 11, 1099–1105, Nov. 1960. (Translation of *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 11, 1649–1657, Nov. 1960 by Amer. Geophys. Union, Washington 5, D.C.)

A mass spectrometer for studying the composition of the atmosphere is described and certain results of observations at great altitudes are presented. From author's summary

Naval Architecture and Marine Engineering

(See also Revs. 5862, 6218, 6228, 6320)

6424. Martin, D. W., Polynomial representation of some ship section area curves and the calculation of the associated wave resistance, *Quart. J. Mech. Appl. Math.* **14,** 1, 49–58, Feb. 1961.

Sectional area curves for three ship models are fitted using Lagrange interpolation and Chebyshev polynomials. Experience using Fourier series is also reported. These results are used to compute wave resistance from a simplified form of Michell's integral. Author concludes that Chebyshev polynomials are superior for this purpose and provide an adequate fit with low degree polynomial.

Results are interesting as regards the representation of an empirical ship curve by standard methods of numerical analysis. However reviewer believes that simplification of Michell's integral so as to depend only on Froude number, sectional area curve, and mean draft of ship may be a serious shortcoming for quantitative calculations. A more precise approach, but one requiring a larger computing effort, would be the use of Michell's integral in exact form together with a two-dimensional polynomial fit of the complete hull, such as that of Kerwin [*J. Ship Res.* **4,** 1, 12–21, 1960]. J. N. Newman, USA

6425. Abal'yants, S. Kh., Experimental tank tests for the determination of hydraulic resistances during the motion of a water mixture (in Russian), *Trudi Sredneaz. Nauk-i, In-ta Irrigatsii* no. 96, 152–155, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13753.

The coefficient of resistance during the motion of a water mixture is presented in the form of the sum total of the basic coefficient of resistance λ_0 in the flow of a pure liquid, a complementary coefficient of resistance to express the increase of friction on the wall λ_1 and a further complementary coefficient of resistance due to the drag on the flow caused by a heavy suspension λ_2. For the determination of the coefficient λ_1 it is proposed to utilize the known data on the motion of pulps in tubes. For the determination of λ_2 experiments were carried out in an open tank (width 105 mm, height 108 mm, and a length for the working part of 2700 mm). The experiments were made with water and a water-sand mixture at a constant temperature of 20°. For the tests, screened and washed sands were used, the hydraulic coarseness of which equalled on an average 6.4 mm/sec, which corresponded to a particle size of 0.09 mm. The depth during the experiments was maintained at a constant figure and equalled 40 ± 1 mm. Measurements were made of the weight concentration in the mixture, the discharge, velocity and hydraulic gradient. An empirical correlation was proposed on the strength of the experimental data for the determination of λ_2.

A. N. Klimentov
Courtesy Referativnyi Zhurnal, USSR

6426. Shearer, K. D. A., and Lynn, W. M., Wind tunnel tests on models of merchant ships, *Inter. Shipbldg. Prog.* **8,** 78, 62–80, Feb. 1961.

To provide accurate data on the wind resistance of certain modern ship designs, wind-tunnel tests have been carried out on 1/60th scale models of a tanker and two cargo ships and on 1/64th scale and 1/128th scale models of a modern passenger liner.

The tanker and cargo-vessel models were tested in three conditions of loading, and the magnitude and direction of the resultant force and moment about amidships for each complete model in the three conditions are given for a free-stream tunnel velocity of 100 ft per second over a range of relative wind from 0 to 180 deg off the bow. These models were tested in a wind gradient.

In the case of the modern passenger liner the larger model was tested in a wind-gradient condition and the smaller model in both the wind-gradient and uniform-wind conditions. The magnitude and direction of the resultant force and moment about amidships were measured. Two 1/128th scale models were used for measuring the wind resistance in the uniform wind condition, one of them acting as a reflexion model.

With the exception of the reflexion model all tests were carried out with the models in the boundary layer close to the tunnel roof. For the 1/64th and 1/60th scale models the resultant velocity gradient was considered to be reasonably close to the gradient obtained under natural conditions above the surface of the sea.

The model results are shown in a nondimensional form using an ahead resistance coefficient K, and are compared with some published data.

Certain possible inaccuracies in applying the model results to the ship conditions are discussed. From authors' summary

6427. Sretenskii, L. N., On wave resistance of a ship in the presence of internal waves (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 56–63, Jan./Feb. 1959.

6428. Khaskind, M. D., Theory of ship resistance in heavy sea (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 2, 46–56, 1959.

6429. Goodman, T. R., and Sargent, T. P., Effect of body perturbations on added mass—with application to nonlinear heaving of ships, *J. Ship Res.* **4,** 4, 22–28, Mar. 1961.

Small perturbation theory is presented for dependence of virtual mass tensor on body shape. Increments of tensor are expressed in terms of fluid pressure before perturbation and geometry of deformation.

In reviewer's interpretation, all results may be derived from principle that increase in kinetic energy of fluid equals work done in expanding body against dynamic pressure. In particular: If dependence of surface pressure p on components of motion c_i $(i = 1 \ldots, 6)$ may be expressed by some symmetrical tensor T_{ik} like $p = T_{ik}c_ic_k$, then increase in virtual mass tensor m_{ik} equals $-2\int T_{ik}\,\delta n dS$, where dS = element of body surface, δn = deformation normal to surface.

Analysis is applied for determination of nonlinear damping of a floating cylinder in heaving motion.

K. Eggers, Germany

6430. Paulling, J. R., The transverse stability of a ship in a longitudinal seaway, *J. Ship Res.* **4,** 4, 37–49, Mar. 1961.

Paper describes experimental and theoretical extensions of similar investigations of Roden and Arndt [AMR 14(1961), Rev. 566] on influence of sinusoidal waves with crests perpendicular to ship's course on stability. Special attention is given to form influence (variation of model geometry from a parent form), influence of ship's speed, and variation of ship-wavelength ratio. Wave steepness is kept constant (1/20). Coincidence between experiments and calculations is good. It is demonstrated that loss in stability essentially concerns residual-stability, whereas metacentric height often increases by presence of waves.

K. Eggers, Germany

6431. Sobolev, G. V., and Fedyaevskii, K. K., Application of low-aspect-ratio wing theory to the solution of problems of ship maneuverability (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Mekh. i Mash.* no. 5, 27–33, 1959.

Paper represents extension of earlier work. The linear part of the generalized forces exerted on the ship moving with a drift angle and with angular velocity are determined using low-aspect-ratio wing theory; nonlinear terms are computed using the well-known cross flow concept. Approximate expressions for the latter are given. Using these values, formulas for the turning radius of steady circulation are given and pertinent results are compared with experimental values due to Davidson and Schiff.

G. P. Weinblum, Germany

6432. Grechin, M. A., Calculations for speeding up and retarding a ship (in Russian), *Trudi Tsentr. Nauk-i. In-ta Morsk. Flota* no. 15, 97–109, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13523.

V. G. Bakaev and V. M. Lavrent'ev showed in their studies [title source 1, 1, 3-35, 1955] that if the force imparting the motion is considered to be a function of the velocity of the ship only then, in the differential equation for the motion of the ship, the variables divide and a solution is obtained in quadratics. In the work being reviewed a successful integration was effected with the aid of supplementary simplifying assumptions, and calculation formulas for different stages in the maneuvering. For calculating the driving of the ship by propeller action the assumption is made that the motive power alters in relation to the velocity in conformity with the linear principle in the range of velocities from zero up to the velocity corresponding with the steady motion of the ship.

When calculating the retardation of the ship under the action of the screw-propeller the process splits up into three periods. In the first period the velocity of the ship remains constant and equal to the velocity of the steady motion up to the moment of cutting off the fuel supply to the motor. In the second period, continued up to the moment of putting the motor in reverse, the motive force is taken to be equal to zero. In the third period the motive force is taken to be equal to the value of the motive force on the hawsers with the screws going astern. The results of the calculations made in accordance with the method proposed were compared with the results of full-scale tests on the tanker "Oleg Koshevoi" and the electric-diesel-engined "Lensovet" when they were in motion from "full speed ahead" up to their coming to a stop with the motors working "full speed astern." The author's data give good correspondence between calculated and experimental velocities as a function of time.

K. K. Fedyaevskii

Courtesy Referativnyi Zhurnal, USSR

6433. Sizov, V. G., The stability of ships carrying granular cargos (in Russian), *Sudostroenie* no. 6, 7–11, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13533.

The circumstances are investigated which occur when static and dynamic moments come into action in a ship carrying cargo of a granular type, and the influence of these moments on the stability of the ship is indicated. A simplified scheme is adopted for the shifting of the granular load, which enables the problem to be solved by the use of elementary methods. It is assumed that: (1) for every cargo of granular material there is a corresponding constant angle of rest, by which is meant the largest angle of slope for the surface of the cargo at which the material remains at rest; (2) sliding of the cargo follows its inclination so that the surface of the load when sliding occurs is inclined the whole of the time to the horizon at the angle of rest. Cases are examined when the pitching moment gives rise to angles of pitch smaller or greater than the angle of rest. The deduction is made that if the angular amplitude of the tossing of the ship exceeds the angle of natural slope then the effect of the granular cargo will be that of a stabilizer of the ship. The shifting of the center of gravity of the cargo and the relation to the angle of slide, as also the shoulder of the heeling pair because of the sliding of the cargo, are determined graphically. The worst case of all—the case of the action of the heeling moment toward the residual angle—is taken to judge the stability of the ship. The smallest dynamic moment required to make the ship capsize is determined by the constructed diagram of stability. It is neccessary to establish the magnitudes of the angles of rest for various granular cargos in different sets of conditions, to develop the character of the sliding of granular cargos and to determine the declination from the plane surface of the oversliding of the cargo.

A. K. Nikitin

Courtesy Referativnyi Zhurnal, USSR

6434. First symposium on ship maneuverability, David Taylor Model Basin, Washington, D. C., May 1960; David W. Taylor Mod. Basin Rep. 1461, 423 pp., Oct. 1960.

6435. Pierson, W. J., Jr., and Dalzell, J. F., The apparent loss of coherency in vector Gaussian processes due to computational procedures with application to ship motions and random seas, New York Univ., Coll. Engng. Res. Div., Dept. Meteorol. Oceangr. Tech. Rep. (Contracts Nonr-285(17) and Nonr-263(09)), 21 pp., Sept. 1960.

6436. Stilwell, J. J., Nelson, P. W., and Porter, W. R., Hydrofoils at the crossroads, *Aero/Space Engng.* **20,** 3, 10–11, 68–73, 75–78, Mar. 1961.

6437. Scordino, P., and Allan, A. E., NVS atomic servant nuclear servicing vessel design B2-MA-51a, *Inter. Shipbldg. Prog.* **7,** 76, 523-531, Dec. 1960.

Friction, Lubrication and Wear

(See also Revs. 6046, 6250, 6395)

Book—6438. Friction and wear in machinery (Translation of the Russian annual, Trenie i iznos v mashinkh, Vol. 12, 1958), New York, American Society of Mechanical Engineers, 1960, x + 334 pp. $7.50. (Paperbound)

"Friction and wear in machinery" is an annual collection of papers in the field of lubrication, friction and wear, published by the Institute for the Science of Machines of the USSR Academy of Sciences. The most important Russian reference source in its field, this series of publications has never before been accessible to those not versed in the Russian language. To alleviate this language difficulty, the ASME Research Committee on Lubrication, through its Subcommittee on Translations, has assumed the respon sibility of rendering English translation. The present volume is a translation of volume 12 (1958) of the Russian series. There are plans to translate at least volume 11 (1957) and all later issues.

The present volume contains 15 papers, and a bibliography on Russian and non-Russian literature in the field for 1954 and 1955. The papers cover topics ranging from hydrodynamic lubrication to boundary lubrication and dry friction and wear. The papers are generally of high quality. The translation is authoritative.

P. M. Ku, USA

6439. Tamai, Y., The friction and contact resistance of metals and alloys in a reciprocating sliding, *ASLE Trans.* **3,** 1, 26-29, Apr. 1961.

A friction pendulum was used in tests with gold, silver, copper, platinum, nickel, aluminum, tin, brass and several steels. Oxide formation was hypothesized to give the increasing electrical contact resistance observed during some tests. Platinum and gold unexplainedly gave considerably higher resistance than silver on silver or silver on steel.

No simple relation was found between friction and contact resistance. Where no oxide films formed, stick-slip sliding gave erratic friction coefficients. E. R. Booser, USA

6440. Huffington, J. D., A theory of friction involving a micro-topographical deformation index, *Wear* **3,** 6, 473-476, Nov./Dec. 1960.

Author examines further his multiple junction theory of friction introduced in a previous paper [*Research* **12,** p. 443, 1959] with reference to the suggested new deformation index determining the real area of contact. Values of this deformation index are computed for different ratios of real area of contact to apparent or indentation contact area from relations between coefficient of friction and mean pressure or load, obtained by other workers from experiments with different surfaces (lubricated rubber against Perspex, abraded and turned Perspex crossed cylinders, run-in brass crossed cylinders). Author concludes that the deformation index-contact area ratio curves for different pressures distinguish the properties of different surfaces independent of the materials of which they are constructed and of the average size of the asperities and enable a classification of surfaces into different kinds. F. Krupka, Czechoslovakia

6441. Rowe, G. W., The friction and strength of clean graphite at high temperatures, *Wear* **3,** 6, 454-462, Nov./Dec. 1960.

Paper describes well done measurements of strength and friction of same type of graphite under same experimental conditions. Results suggest that under heavy loads the friction of graphite is increased considerably by outgassing, but then falls as the specimen temperature is raised. Experiments show that strength of outgassed graphite is independent of temperature up to 1800 °C and the strength of not previously outgassed increases by 30% between 20 °C and 1600 °C. Results enphasize the importance of controlling the atmosphere for measurements of the mechanical as well as the frictional properties of graphite.

J. A. Cintra, Brazil

6442. Manteuffel, A. A., and Wolfram, G., A method for studying the effect of extreme pressure additives on rubbing metal surfaces, *ASLE Trans.* **3,** 2, 157-164, Oct. 1960.

A new modification of the Shell four-ball machine is described in which a thermocouple is installed near the center of the tetrahedron so as to sense the temperature of the oil as it leaves the area of the rubbing surfaces. The loading of the machine is programmed to increase at 10 kg per minute. The friction force is also measured. A recorder is provided to indicate simultaneous measurements of temperature, friction, and load. For mineral oils the temperature rise is approximately proportional to the load. Extreme pressure compounded oils are characterized by abrupt changes in temperature at loads characteristic of the additives. The friction force follows the temperature quite closely. The transition points are accompanied by rapid wear and decrease in unit loading. Phosphate coating of the balls results in increased temperature at the same load. This indicates that phosphate coating increases friction rather than decreasing it.

Reviewer believes that this work is an interesting adaptation of the four-ball machine and that the method is capable of elucidating further the mechanism of extreme pressure lubrication.

J. W. Givens, USA

6443. Kragelsky, I. V., and Demkin, N. B., Contact area of rough surfaces, *Wear* **3,** 3, 170-187, May/June 1960.

A model consisting of a truncated cone with a spherical top is used to calculate the variation with load of the contact area of surfaces that are rough and wavy. From the elasto-plastic properties of this model of a unit protrusion, a formula is deduced for the real contact area as a function of load, surface geometry, and material properties. Analysis is very approximate and depends on empirical factors determined for each material.

P. Seide, USA

6444. Genkin, M. D., Kuz'min, N. F., and Misharin, Yu. A., Influence of regimes of friction on the coefficient of friction during rolling with slipping (in Russian), *Izv. Vyssb. Uchebn. Zavedenii: Mashinostroenie* no. 2, 21-28, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13083.

An examination is made of the friction on lubricated roller-bearing test samples manufactured from steels of different marks. The friction was studied at velocities for the slip up to 12m/sec and contact shear stresses of up to 3000 kg/cm². On the basis of the analysis of the results obtained, authors conclude that the coefficient of friction of different samples which have been lubricated (1) does not depend on the materials of the bodies rubbing together, (2) alters little with changes in the contact pressure, (3) falls with increase in the velocity of slipping and the aggregate velocity of rolling, (4) increases with increase in the volumetric temperature of the bodies rubbing together, (5) decreases with increases of the initial viscosity of the lubricating oils. The experiments were carried out to clarify the principles of friction in cut gears. G. D. Lomakin

Courtesy Referativnyi Zhurnal, USSR

6445. Niemann, G., Rettig, H., and Lechner, G., Scuffing tests on gear oils in the FZG apparatus, *ASLE Trans.* **4,** 1, 71–86, Apr. 1961.

The FZG test is a usual and standardized method in West Germany to evaluate the antiscuffing properties of oils for reduction gears, hypoid gears, automatic transmission gears, etc. The paper gives a brief survey of the test apparatus, the test gears, and the test procedure. It describes also the criteria of failure and the evaluation of the results, taking into account not only the load-carrying capacity but also the wear performance of an oil. The repeatability and the scattering range is discussed with respect to the test conditions. The field of application for standardized gear rigs is pointed out. This is followed by a discussion of results showing the effect of tooth profile, mineral and synthetic oils, pitch line velocity, temperature, and surface treatment on the load-carrying capacity.

Furthermore the paper presents a formula to transfer the obtained test results to other gears. Results of the FZG apparatus are compared with values obtained on Ryder and IAE machines.

From authors' summary

6446. Beerbower, A., and Greene, D. F., The behavior of lubricating oils in inert gas atmospheres, *ASLE Trans.* **4,** 1, 87–96, Apr. 1961.

The interactions of five gases (helium, hydrogen, nitrogen, argon, and carbon dioxide) with mineral and synthetic lubricating oils were studied. The interactions examined included gas solubility, foaming, entrainment, evaporation of oil into gas, stability of oil in presence of gas, and effect of dissolved gas on oil viscosity. Several of the gases showed behavior (appreciably different from that of air) that was not predicted by conventional theories. No important differences were found between mineral and synthetic (diester) oils in these respects. The additives used can have appreciable influence on the foaming and entrainment characteristics, and evaporation rates, of both types of oils.

From authors' summary

6447. MacConochie, I. O., and Newman, W. H., Jr., The effect of lubricant viscosity on the lubrication of gear teeth, *Wear* **4,** 1, 10–21, Jan./Feb. 1961.

The film thicknesses experimentally obtained through "sustained electrical discharge" technique of Cameron [*J. Inst. Petrol.* **40,** no. 367, p. 191, 1954] are essentially similar to those in Cameron & MacConochie's ASME Paper no. 58-A-142. Authors attempt to explain their experimental results by means of a theoretical approach, based on the assumption that the lubricant would show a viscoelastic (Maxwellian) behavior. Since there are some speculative elements in this approach, the authors' qualification "preliminary" should not be disregarded.

H. Blok, Holland

6448. Shawki, G. S. A., Rippled bearings for high speed journals (in English), *Acta Techn. Nakladatelstvi Ceskoslovenske Akad.* **5,** 3, 213–227, 1960.

The performance of the rippled bearing is obtained for concentric running of journal, two cases of film extent being considered, viz. full- and partial-width films. The results are compared with those of the elliptical (2-lobe) bearing on basis of equal size, mean clearance and minimum film thickness. The rippled bearing is shown to give invariably lower friction than the elliptical bearing, the difference attaining some 10% at the higher values of the amplitude ratio. Moreover, while an increase in the number of lobes (e.g. 3-lobe and 4-lobe bearings) results in higher friction ..., an increase in the number of ripples ... produces no change in friction. It can be concluded therefore that, in this respect, the rippled bearing is superior to the multi-lobe bearing.

The rippled bearing is also found to have higher end flow than that of the elliptical bearing provided the number of ripples is at least three. These performance characteristics of the rippled bearing result in relatively reduced power loss, hence higher bearing efficiency, also lower operating temperature and greater journal stability. Such qualifications may well recommend this type of bearing as a satisfactory solution to the problem of bearing design for high-speed journals.

From author's summary by T. Ranov, USA

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INDIAN INSTITUTE OF TECHNOLOGY,
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The Indian Society of Theoretical and Applied Mechanics
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INDEX OF AUTHORS REFERRED TO IN THIS ISSUE

(NUMBERS USED ARE SERIAL NUMBERS OF REVIEWS)

Aadnesen, L. 5970
Abal'yants, S. Kh. 6425
Abarbanel, S. S. 6271
Abeles, B. 6312
Abramson, H. N. 6270
Adamson, T. C., Jr. 6373
Adrianov, V. N. ..6303, 6304
Agarov, V. A. 5893
Albertson, M. L. 6124
Aleksandrov, B. K. 6241
Allan, A. E. 6437
Allen, D. N. de G. 6090
Alterman, Z. 6215
Altshuler, L. M. 6284
Ambartsumian,
S. A. 5948, 5964
Andersen, W. H. 6176
Ang, D. D. 6015
Antonescu, I. P. 6034
Apelt, C. J. 5823
Arai, T. T. 5856
Arkharov, V. I. 6072
Arons, A. B. 6378
Aronson A. Ya. 5994
Astrakhan, I. M. 5907
Axelrad, D. R. 5940
Bahn, G. S. 6256
Baldwin, L. V. 6198
Balueva, A. S. 6227
Baradell, D. L. 6165
Baron, F. 6105
Barta, J. 5971
Barthelemy, J. 5960
Barton, J. R. 6124
Bassali, W. A. 5943
Bate, R. T. 6313
Batenchuk, E. N. 6127
Bayuk, E. I. 6076
Bazilevskii, N. G. 6051
Bechert, H. 5951
Beckwith, T. G. 5847
Bedel'baev, A. K. 5851
Beerbower, A. 6446
Beers, D. S. 6312
Bekarevich, I. L. 6265
Belen'kii, M. Ia. 5875
Belotelov,
V. L. 6409, 6413, 6415
Belotserkovskii, O. M. ..6205
Bennett, A. G. 6363
Benzler, H. 6309
Beranek, L. L. 6380
Bernard, J. -J. 6255
Bertram M. H. 6165
Berzon, I. S. 6221
Besseling, J. F. 5884
Biderman, V. L. 6000
Bieniek, M. P. 5956
Biianov, G. F. 6127
Binder, J. A. 6311
Bird, J. F. 6328
Birkhoff, G. 5827
Blanche, J. F. 6110
Bleines, W. 6136
Blizard, J. R. 6077
Blokh, V. I. 5894
Blythe, P. A. 6174
Boehm, J. 6110
Bogusz, W. 5845
Bohlin, T. 6144
Bonnell, J. M. 6315
Borchers, K. -O. 6274
Bottema, O. 5838
Bourdon, C. 6237
Bouwhuis, G. J. 6394
Bowman, C. W. 6308
Boyd, E. A. 6163, 6164
Boyer, D. W. 6180
Bramble, J. H. 5876
Brenkert, K., Jr. 6142
Brissenden, R. F. 6364
Brockhurst, R. R. 6378
Brooks, G. W. 6213
Brouwer, D. 6354
Brovman, M. Ya. 6112
Brownlee, K. A. 5817
Bruce, J. G., Jr. 6378
Brusilovskii, I. V. 6248
Buck, N. L. 5487
Bukhin, B. L. 6000
Bulin, N. K. 6411
Bull, A. F. 5831
Burgess, E. 6355
Burry, R. V. 6326
Burton, B. B. 6364
Bushel', A. R. 6249
Bushmanov, V. K. 6189
Bushuev, L. P. 6108
Businger, J. A. 6300
Bychkov, D. V. 5935
Bykovtsev, G. I. 5917
Cahn, M. S. 6210
Calcan, V. I. 5835, 5836
Campbell, J. S. 6038
Carafoli, E. 6203
Chaevskii, M. I. 5880
Chahine, M. T. 6160
Chang, C. T. 6149
Chang, I-D. 6344
Chao, B. T. 5828
Chavtoraev, A. I. 6132
Cheers, F. 6292
Chen, S. -Y. 6276
Cheng, S. -Y. 6100
Cherdantsev, V. V. 6006
Cherkesov, L. V. 6222
Chernyshev, V. I. 5867
Cherry, S. 5972
Chitty, Letitia 6089
Chu, W. H. 6270
Chudnovsky, A. F. 6275
Chuvilovskii, V. S. 5990
Cicala, P. 5954
Clemence, G. M. 6354
Clyne, G. 6055
Cody ,G. D. 6312
Coffin, J. 6250
Cohen, E. G. D. 6261
Cohen, M. J. 6152
Coleman, B. D. ...5908, 5909
Collatz, L. 5816
Collins, D. 5887
Collins, W. D. 5815
Colonnetti, G. 5896
Comolet, R. 6243
Conway, H. D. 5941
Cook, R. 6153
Cooke, J. C 6182, 6187
Corliss, W. R. 6325
Curle, N. 6192
Dalzell, J. F. 6435
Daniliuk, I. I. 5810
Danilov, V. K. 6119
Dano, S. 5818
Davis, C. D. 6058
Davis, R. S. 5821
Dean, R. C., Jr. 6214
Dehousse, N. M. 6128
de Leiris, H. 5960
Dellos, K. P. 5901
Dem'ianov, Iu. A. 6184
Demkin, N. B. ...6443, 6279
Deribas, A. A. 6005
de Soto, S. 6194
de Vries, G. 6353
Dikii, L. A. 6217
Dinkelacker, A. 6388
Di Ricco, G. 6251
Diskin, M. H. 6134
Dmitriev, V. N. 5867
Dobrokhotov, V. P. 5914
Doebler, R. L. 6327
Donskov, S V. 6278
Dorodnitsyn, A. A. 6183
Dovnorovich, V. I. 5895
Duck, W. 5830
Dugundji, J. 6003
Duke, W. M. 6357
Dusinberre, G. M. 6281
Dzhanelidze, G. Yu. ...5891
Ehrlich, L. W. 5809
Eickner, H. W. 6120
Eide, D. G. 5839
Elistratov, F. M. 6319
Emmons, H. W. 6149
Epinat'eva, A. M. 6225
Ershov, L. V. 5922
Eshelby, J. D. 5888
Eulner, R. 6317
Falkovich, S. V. 6155
Farber, S. J. 6084
Farzetdinov,
M. M. 6289, 6297
Fedyaevskii, K. K. 6431
Feind, K. 6150
Feofilaktov, D. V. 6413
Feringer, B. P. 6126
Ferrero, M. A. 6385
Fessler, H. 6053, 6055
Finnie, I. 5903
Fisenko, G. L. 6030
Flinn, R. A. 6067
Flügge-Lotz, I. 5858
Fontein, F. J. 6404
Foreman, J. J. 6053
Forman, G. W. 6246
Foudriat, E. C. ...5864, 6364
Fralich, R. W. 6063
Freudenthal, A. M. 5956
Freund, P. 6047
Friauf, J. B. 6262
Frick, C. W. 6329
Friedlander, S. K. 6151
Frohberg, M. G. 6258
Frost, V. A. 6200
Fukusawa, K. 6252
Fulkerson, D. R. 5820
Furduev, V. V. 6381
Gabrielli, G. 6116
Gaidukov, M. G. 6071
Gakhov, F. D. 5811
Gamainov, A. I. 6029
Gamble, E. H. 5854
Ganin, E. A. 6279
Garabedian, H. L. 5827
Garden, R. J. P. 6080
Gatewood, B. E. 5881
Gavrilov, A. F. 6398
Gavrilov, Yu. V. 5997
Gazizov, B. G. 5983
Gazzara, C. P. 6070
Gee, A. F. 6088
Geller, S. Iu. 6422
Geniev, G. A. 6026
Genkin, M. D. 6444
Geogdzhaev, V. O. 5930
Gerard, F. A. 6098
Gersten, K. 6209
Gerstle, K. H. 6106
Getmanskaya, M. V. ...6399
Gille, J.-C. 5852
Gilvarry, J. J. 6359
Gints, A. S. 6131
Girardin, P. 6321
Gladkovskii, V. A. 6118
Glaettli, H. H. 5866
Glauert, M. B. 6342
Gluzmann, A. M. 6418
Goflin, A. P. 6238
Goldberg, E. A. 6357
Golecki, J 5871
Golubkov, V. N. 6031
Golubev, V. V. 6146
Goncharov, Yu. M. 6031
Gontier, G. 6156
Goodman, T. R. 6429
Goodson, K. W. 6212
Gorcey, R. 5961
Gordon, B. M. 5857
Gottlieb, P. 6376
Graham, R. W. 6306
Grantham, W. D. 6361
Grechin, M. A. 6432
Green, A. P. 6040
Green, H. 6036
Greene, D. C. 5995
Greene, D. F. 6446
Greenspan, H. P. 6343
Griffin, J. A., Jr. 5825
Grothouse, A. P. 5881
Grubnik, N. A. 6027
Gurevich, M. I. 6135
Gurtin, M. E. 5931, 6008
Gusein-Zade, M. I. 6016
Gutkin, A. M. 5906
Guyot, Mrs. M. T. 6226
Hahn, R. S. 6044
Hale, F. E. 6379
Hanna, N. O. M. 5943
Hansen, Q. M. 5837
Harada, I. 6288
Harada, M. 6216
Hardenberg, D. E. 6052
Harris, R. J. 6369
Harrison, A. C. 6257
Hart, R. W. 6328
Hashin, Z. 5890
Haskell, R. N. 6201
Hassan, H. A. 6181
Hatch, L. P. 6330

INDEX OF AUTHORS REFERRED TO IN THIS ISSUE *(Continued)*

(NUMBERS USED ARE SERIAL NUMBERS OF REVIEWS)

Hausner, H. H. 6064
Havenaar, I. 6405
Hawthorne, W. R. 6318
Hayashi,
T. 5963, 5966, 6230
Hayes, R. 6332
Heckl, M. 6382
Heckmann, W. K. 6054
Heller, H. 6386
Henry, I. G. 6323
Herrmann, A. L. 6110
Hewlett, P. M. 6097
Heyson, H. H. 6247
Hickey, D. H. 6245
Hieser, G. 6158
Hilton D. A. 6384
Hirschfelder, J. O. 6259
Hockett, J. E. 6039
Hocking, L. M. 6147
Hodge, P. G., Jr. 5921
Holl, H. B. 6365
Holsters, H. 6138
Hornig, D. F. 6176
Hother-Lushington,
Miss S. 6078
Houghton, D. S. 5984
Hsu, C. S. 5870
Hsu, Y. -Y. 6306
Hubbard, H. H. 6384
Huffington, J. D. 6440
Hunt, J. N. 6179
Hunter, S. C. 6058
Iguchi, M. 6252
Il'iushin, A. A. 5911
Ille, V. 5944
Il'yushin, A. A. 5974
Isaev, V. S. 6012
Ivanov, A. N. 6139
Ivanova, T. G. 6235
Ivanyan, V. M. 6075
Ivlev,
D.D. .5897, 5913, 5917, 5929
Ivyanskii, G. B. 6122
Iwanami, S. 6253
Jackson, T. W. 6294
Jacobs, H. 6355
Jaffe, R. I. 6065
Jain, A. C. 6202
Jain, O. P. 6087
James, J. F. P. 6078
James, R. L., Jr. 6369
Jenness J. R., Jr. 6367
Johannesen, N. H. 6175
John, F. 5877
Johns, D. J. 5984
Johnsen, I. A. 6240
Johnson, A. I. 6308
Jortner, J. 6326
Jung, I. 6320
Kaczmarek, J. 6045
Kaichev, P. 6236
Kallistratova, M. A. 6389
Kalpakcioglu, S. 6043
Karplus, W. J. 5832
Kats, M. M. 6021
Kaul, C. N. 6339
Kautz, Barbara R. 5995
Kayama, N. 6048
Keilis-Borok, V. I. 6419
Kelly, N. W. 6246
Kezdi, A. 6033
Khachiyan, M. G. 6061
Khalatnikov, I. M. 6265
Khamrui, S. R. 6148
Khaskind, M. D. 6428
Khorosheva,
V. V. 6410, 6414
Khosla A. N. 6099
Kingery, W. D. 6066
Klein, B. 5822
Klein, G. H. 6007
Klier, E. P. 6070
Kloppel, K. 5949
Klyachko, L. S. 6399
Kneschke, A. 6393
Kogan, M. N. 6345
Kolesnikov, K. S. 5991
Komarovskii, L. V. 6161
Kondorskaya,
N. V. 6409, 6415
Konovalov, M. D. 6056
Konowallow, D. D. 6259
Konstantinova,
A. G. 6412, 6416
Korbukova, L. D. 5962
Korneev, N. I. 6068
Kornishin, M. A. 5982
Korobeinikov, V. P. 6341
Kosmodamianskii, A. S. .5967
Kosten, C. W. 6383
Krafft, J. M. 6069
Kragelsky, I. V. 6443
Krasnikov, N. D. 6005
Kravtsov, G. S. 6017
Krivosheev, N. I. 5988
Krochmann, E. 5869
Kudryavtsev, I. V. 6117
Kuhn, P. M. 6300
Kuhn, R. E. 6211
Kuklin, V. B. 6111
Kulakowski, L. J. 6201
Kunin, I. A. 6234
Kurdin, N. S. 5916
Kurdyumov, A. A. 6001
Kuroyanagi, J. 6073
Kussner, H. G. 6154
Kuzin, P. A. 6016
Kuz'min, N. F. 6444
Kvitka O. L. 5893
Labuntsov, D. A. 6307
Ladyzhenskii, M. D. ...6169
Laing, R. A. 6140
Lambert, R. F. 6390
Lamper, R. E. 6349
Langer, R. E. 5824
Lapidus, L. 5821
Lavrentyev, S. A. 6273
Lechner, G. 6445
Lee, S.-Y. 5865
Leeden, P. v. d. 6394
Leites, S. D. 5947
Lekhnitskii, S. G. 5965
Lemke, C. E. 5919
Lemlich, R. 6298
Leniger, H. A. 6401
Levi, R. 5980
Levina, Z. M. 5945
Levitin, L. B. 6334
Levy, M. R. 6298
Li, H. L. 5828
Lieblein, S. 6240
Lighthill, M. J. 6336
Lihou, D. A. 5831
Liley, J. N. 6292
Lilly, G. M. 6254
Lin, T. H. 5910
Lippitt, M. W., Jr. 6263
Lipps, H. 6178
Lomakin, V. A. 5883
Lorenz, H. 6032
Lougher, E. H. 6313
Louzhnov, G. K. 6398
Lowan, A. N. 6277
Lowe, R. E. 6104
Luecke, E. I. 6417
Lyamshev, L. M. 6377
Lynn, W. M. 6426
McClure, C. L. 5863
McClure, F. T. 6328
McGonnagle, W. J. 6057
McIntyre, V. 6287
McKenzie, K. I. 5987
McNiven, H. D. 6022
MacConochie, I. O. 6447
MacDonald, R. J. 6109
Macinante, J. A. 5844
Madewell, J. F. 6104
Madigan, J. R. 5856
Maglieri, D. J. 6384
Makarov, L. O. 6114
Makhortykh, Zh. K. 6351
Makhovikov, V. I. 6268
Maki, R. L. 6245
Mal'chikov, S. V. 5848
Manacorda, T. 5879
Manevich, I. L. 5977
Mansfield, E. H. 6103
Manteuffel, A. A. 6442
Manya, V. 5937
Marchenko, B. M. 6233
Marchenko, L. L. 6005
Marcu, V. V. 6047
Margulis, A. I. 6049
Martin, D. W. 6424
Martorana, S. 6302
Maslach, G. J. 6160
Massonnet, C. 5981
Masubuchi, K. 6113
Mathey, R. G. 6086
Mazy, G. 5981
Mednikov, I. A. 6035
Medukhovskii, I. B. 6204
Meier, H. 6218
Meister, E. 6239
Mertens, J. 6317
Metelitsyna, G. G. 6232
Metenin, V. I. 6260
Meyer, E. 6388
Mezhirov, I. I. 6293
Miles,
J. W. 6014, 6018, 6374
Minagawa, S. 5860
Mirels, H. 6195
Misharin, Yu. A. 6444
Mishchenko, P. D. 5936
Mitnik, G. S. 6082
Mityushkin, Yu. I. 6244
Miyagawa, M. 6042
Mlgaard, J. 6046
Mochalin, A. I. 6282
Monin, A. S. 6197
Morgan, B. B. 6395
Morton, D. 6254
Moskvitin, V. V. 5923
Moulic, E. S. 6160
Movchan, A. A. 6348
Mugler, J. P., Jr. 6210
Musen, P. 6358
Mushtari, Kh. M. 5959
Myerson, A. L. 6257
Naghdi, P. M. 5870
Nakamura, K. 6288
Nakamura, S. 6037
Nakatani, M. 6288
Namestnikov, V. S. 5900
Nastase, Adriana 6203
Naumchenkov, N. E. ...6117
Nechleba, M. 6242
Neimark, Yu. I. 5855
Nelson, P. W. 6436
Nemchinov, I. V. 6301
Nemirovskii, Yu. V. 5882
Neuber, H. 5999
Nevzglyadov, V. G. 6196
Newman, W. H., Jr. 6447
Nichols, L. D. 6366
Nicklas, J. C. 5854
Niemann, G. 6445
Nigul, U. 5957
Nikitin, A. T. 6280
Nishikawa, K. 6295
Nitetskaya, I. B. 6093
Noll, W. 5908, 5909
Nomicos, G. N. 6391
Norman, W. S. 6287
Norton, H. T. Jr. 6157
Nougaro, J. 6226
Novikov, E. A. 6347
Novozhilov, V. V. 5872
Odqvist, F. K. G. 5898
Okita, H. 6048
Oldenburger, R. 5854
Olson, W. T. 6318
Olson, W. Z. 6120
Olstad, W. B. 6210
Olszak,
W. 5915, 5927, 5928
Ondra, O. 5833
Ormerod, A. 5920
Osborn, J. R. 6315
Ostromentskii, Yu. Ts. ..5934
Otis, J. H., Jr. 6212
Otto, G. 6102
Ovcharenko, I. Kh. 6129
Ovcharov, E. E. 6137
Pandratov, S. A. 6023
Panichkin, I. A. 5808
Patel, S. A. 5899
Patterson, G. B. 6368
Paulling, J. R. 6430
Pavlov, V. A. 6071
Pavlov, V. P. 6123
Pei, M. L. 6004
Pelecudi, C. 5835, 5836
Perkins, F. M. 6362
Perzyna, P. 6019, 6025
Peterson, J. P. 5978
Petrov, N. A. 6130
Pfeffer, I. 6357
Picot, J. J. C. 6290
Pierson, W. J., Jr. 6435
Pippard, A. J. S. 6089
Pirogov, I. M. 5958
Pirozhkov, G. I. 6085

INDEX OF AUTHORS REFERRED TO IN THIS ISSUE *(Continued)*

(NUMBERS USED ARE SERIAL NUMBERS OF REVIEWS)

Pirvulescu, N. S. 5973
Pister, K. S. 5950
Plakida, M. E. 6232
Pivnev, F. A. 5924
Podstrigach, Ya. S. 5880
Pogodin-Alekseev, G. I. 5926
Pogorzelski, W. 5812
Pokhunkov, A. A. 6423
Polovin, R. V. 6337
Ponsford, H. T. 6104
Poppleton, E. D. 6092
Porter, W. R. 6436
Postnikov, V. S. ..5902, 6010
Potter, R. L. 6317
Powell, J. R. 6330
Pozharitskii, G. K. 5841
Prager, W. 5905
Prasad, C. 5989
Prikov, M. M. 6095
Pshenichnov, G. I. 5985
Purdy, K. R. 6294
Pykhteev, G. N. 6135
Raetz, R. V. 5952
Raezer, S. D. 6314
Rajaratnam, N. 6133
Ramachandran, S. 5992
Ransford, G. 6230
Rao, N. S. G. 6141
Ratnikova, L. I. 6223
Redshaw, S. C. 5834
Reese, D. J. 6067
Reeves, B. L. 6340
Regan, W. H. 6330
Reshetov, D. N. ..5945, 6111
Rettig, H. 6445
Riazanov, E. V. 6341
Rietema, K. 6402
Rikhter, V. A. 6056
Riley, J. D. 5809
Riznichenko, Y. V. 6421
Roberts, S. M. 5821
Romaniv, O. N. 5993
Rorschach, H. E., Jr. ...6140
Rosciszewski, J. 6162
Rosemary, J. K. 6326
Rosen, E. M. 6285
Ross, A. J. 6208
Ross, C. 5953
Rowe, G. W. 6441
Rowland, W. R. 6191
Rudiger, D. 6143
Rumiantsev, B. N. 6220
Runckel, J. F. 6158
Rutishauser, H. 5826
Ruzicka, J. E. 5843
Ryhming, I. L. 6173
Rykunov, L. N. 6414
Rytov, S. M. 6371
Sacerdote, G. G. 6385
Saether, K. 6081
Sakai, S. 5840
Saltanov, N. V. 6338
Salvadori, M. G. 6024
Samul', V. I. 5942
Sandomirskii, M. G. 6396
Sankaranarayanan, R. ..5955
Sapozhnikov, V. G. 6030
Sargent, T. P. 6429
Sata, T. 6059
Savarensky, E. P. 6409, 6413
Savina, A. A. 6399
Savinov, G. V. 6013
Sax, E. 5821
Schaaf, S. A. 6160
Schapink, F. W. 6060
Schardt, R. 5949
Schenck, H. 6258
Schmidt, Th. E. 6286
Schmitt, K. 6397
Schneeweiss, G. 6266
Schock, M. 6393
Schwarze, G. 5849
Scordino, P. 6437
Scott, E. J. 5828, 6285
Seaver, W. H. 5857
Sedov, V. V. 6414
Seetharamaiah, K. 6141
Seitz, R. N. 6332
Sellers, J. P., Jr. ..6283, 6291
Selwood, A. 6046
Sengers, J. V. 6261
Senoo, Y. 6214
Serbin, H. 6159
Sesonske, A. 6299
Sevast'yanov, N. V. 6005
Sevast'yanov, V. Ya. 6050
Severn, R. T. 6090
Shamina, O. G. ..6229, 6421
Shankin, P. A. ...6028, 6228
Sharbaugh, A. H. 6263
Shawki, G. S. A. 6448
Shchukin, V. A. 6322
Shearer, K. D. A. 6426
Sherbourne, A. N. 5979
Shesterikov, S. A...5904, 5912
Shevlyakov, Yu. A. 5977
Shil'nikov, L. P. 5855
Shimada, H. 5939
Shimanov, S. N. 5842
Shkerbelis, K. K. 6083
Shlikov, U. P. 6279
Shmanenkov, V. N. 6184
Shtokalo, I. Z. 5807
Shubin, V. P. 5925
Shuvalov, S. A. 6111
Shyakhtin, A. V. 5998
Signorini, A. 5873
Silberman, E. 6125
Silveira, M. A. 6213
Simon, R. 6313
Simons, D. B. 6124
Sirotina, E. P. 6346
Sizov, V. G. 6433
Skalak, R. 6024
Skudrzyk, E. J. 5995
Skugarev, I. G. 6068
Slater, J. M. 5868
Slocum, R. W., Jr. 6331
Smirnov, V. I. 5813
Smith, M. W. 6390
Sobolev, G. V. 6431
Sobolev, Yu. S. ..5889, 6074
Soroka, W. W. 5832
Sorokin, M. P. 6296
Spangenberg, W. G. 6191
Spence, D. A. 6186
Spurlock, J. M. 6294
Spurr, R. T. 6387
Sretenskii, L. N. 6427
Stakhanov, I. P. ..6170, 6171
Stallard, D. V. 5862
Stanyukovich, K. P. 6334
Starczewski, J. 6310
Stark, V. J. E. 6352
Starkweather, W. 6101
Starzewski, K. 6091
Steinmetz, E. 6258
Stepanov, R. D. 6350
Stepanskii, L. G. 5918
Stesin, I. M. 6419
Stilwell, J. J. 6436
Stojanovitch, R. 5886
Stone, M. W. 6324
Strand, T. 6329
Strang, W. G. 5809
Straub, L. G. 6125
Strejc, V. 5850
Strel'bitskaya, A. I. 5919
Stuhlinger, E. 6332
Stupochenko, E. V. 6170, 6171
Sullivan, A. M. 6069
Swamy, N. V. C. 6141
Swann, R. T. 6305
Sweeny, R. F. 5821
Sychev, V. V. 6166, 6167
Sykes, A. O. 6009
Syrovat-Skii, S. I. 6346
Szaniawski, A. 6177
Szechy, K. 6033
Szelagowski, F. 5878
Tack, D. H. 6390
Takizawa, E. I. 6121
Tamai, Y. 6439
Tamm, K. 6388
Tanghe, A. 5981
Tanner, C. B. 6300
Taranova, G. M. 6199
Tarapin, V. N. 6056
Tarasenko, I. I. ..5933, 5976
Tartakovskii, G. P. 5859
Tatarskii, V. I. 6389
Temple, G. F. J. 5823
Teodorescu, P. P. 5874, 5885, 5932
Tesarzhik, I. 6392
Tesson, F. 6321
Theilheimer, F. 6101
Thirriot, Cl. 6226
Thom, A. 5823
Tien, C. 6267
Tindall, R. B. L. 6115
Tirskii, G. A. 5892
Tkalich, V. S. 6338
Trass, O. 6308
Troesch, B. A. 5809
Trofimov, E. P. 6272
Trojan, P. K. 6067
Truesdell, C. 5938
Tryufil'kina, E. I. 6411
Tsao, S. 6224
Tsatskis, V. I. 5975
Tsepelev, N. V. 6020
Tsoi, P. V. 6269
Tsvei, I. Yu. 6420
Tsypkin, Ya. Z. 5861
T'ung, C. 6381
Uematu, T. 6037
Uflyand, Ya. S. 6333
Umanskii, E. S. 5893
Unksov, E. P. 5918
Urbanowski, W. 5927
Ury, J. F. 5846
Ushakov, K. A. 6249
Van der Kolk, H. 6406
Van Kooy, J. G. 6403
Vanoni, V. A. 6391
Vasil'ev, L. I. 6062
Vasil'eva, A. G. 5926
Vathitov, M. B. 6002
Vekua, I. N. 5986
Venkatraman, B. 5899
Vinogradov, G. V. 6123
Von Hausen, W. W. 5881
Wallace, J. F. 6041
Wallis, R. A. 6193
Walsh, T. J. 6198
Walz, A. 6185
Wani, T. 6206
Warburton, F. L. 6078
Ward, D. M. 6308
Wasko, R. A. 6190
Watermeier, L. A. 6316
Watson, B. C. 6149
Watstein, D. 6086
Wegrzyn, S. 5852
Weidlinger, P. 6024
Weirauch, R. F. 6360
Wen, W. L-S. 6356
Werner, J. E. 6172
Werner, P. 6375
Westpfahl, K. 5814
Westwood, D. 6041
Wetzel, S. 6107
Whitbeck, R. F. 5853
Whitcomb, C. F. 6157
White, J. S. 5837
Whitham, G. B. 6219
Whitley, R. O. 5978
Whitten, J. B. 6364
Williams, M. L. 5950
Wilson, R. W. 6055
Woeber, W. A. 6096
Wolf, H. 6194
Wolfram, G. 6442
Wolska-Bochenek, J. ...6145
Wolters, H. B. M. 6060
Wood, R. M. 6104
Wood, W. W. 6372
Wuest, W. 6207
Wyatt, P. J. 6370
Wynn, P. 5829
Yakutovich, M. V. 6072
Yang. K. -T. 6188
Yin, M. 5858
Yoshikawa, H. 6059
Yoshiyama, R. 6408
Yukubenko, A. E. 6335
Yusuff, S. 6079
Yuzefovich, G. I. 6011
Zak, L. V. 5946
Zakkay, V. 6168
Zappala, A. G. 6331
Zevakhin, O. K. 6094
Zhamagortsyan, V. N. ..6231
Zhilin, N. V. 6005
Zhodzishtii, G. A. 5996
Zubchaninov, V. G. 5968, 5969
Zucker, I. J. 6264
Zukoski, E. E. 6256
Zverev, N. I. 6398